1/116

1-SIDED TUNNEL SYSTEM

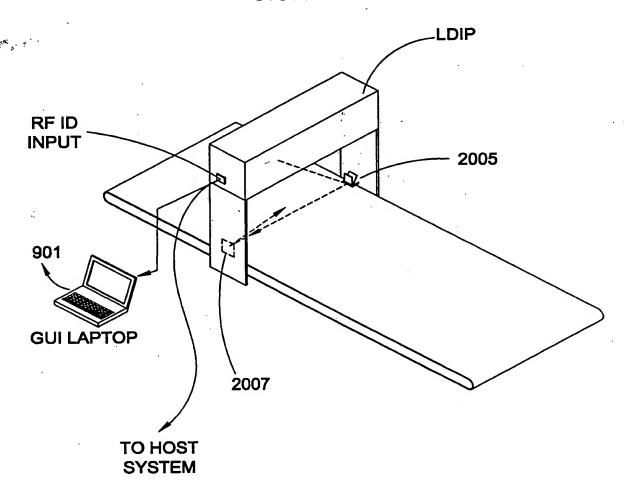


FIG. 1A

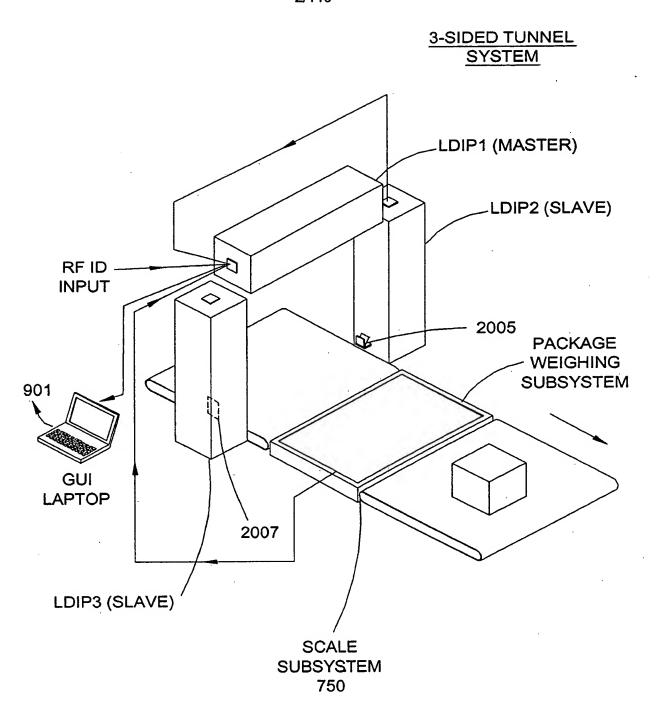


FIG. 1B

3/116

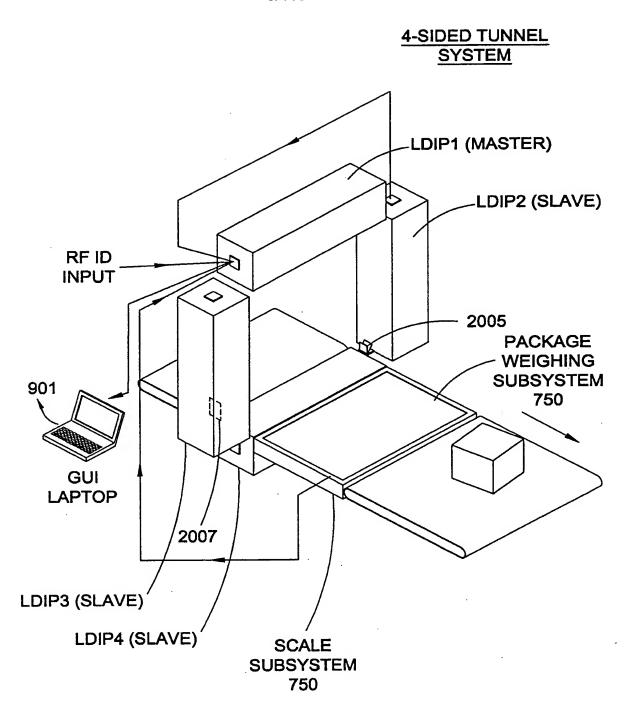


FIG. 1C



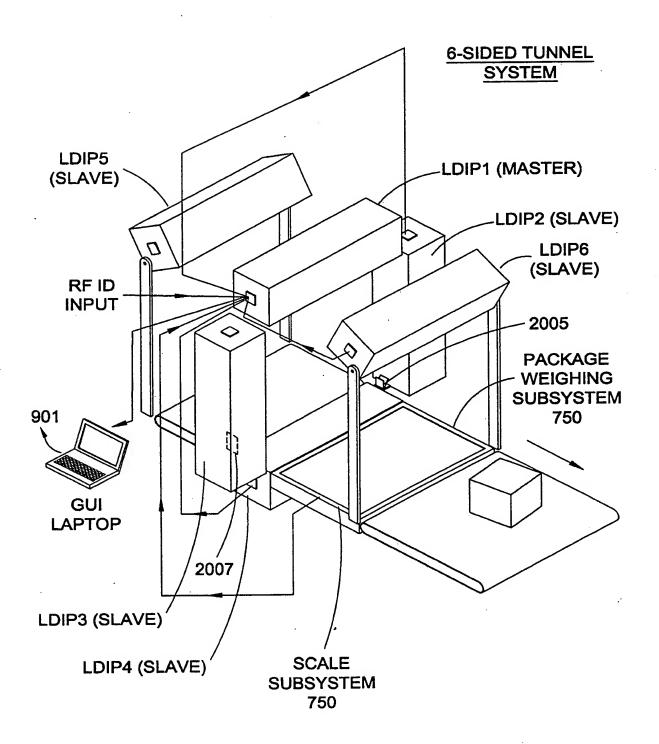


FIG. 1D

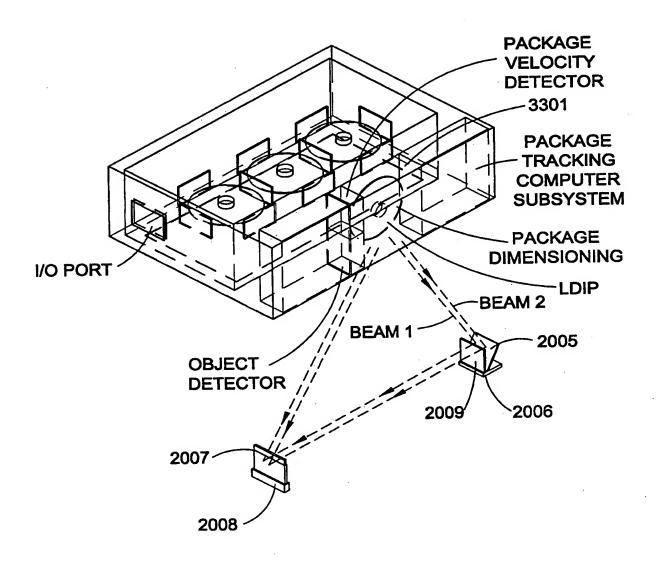


FIG. 2A

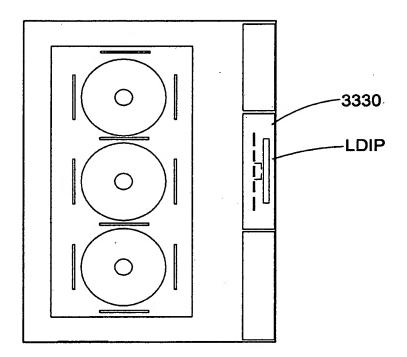
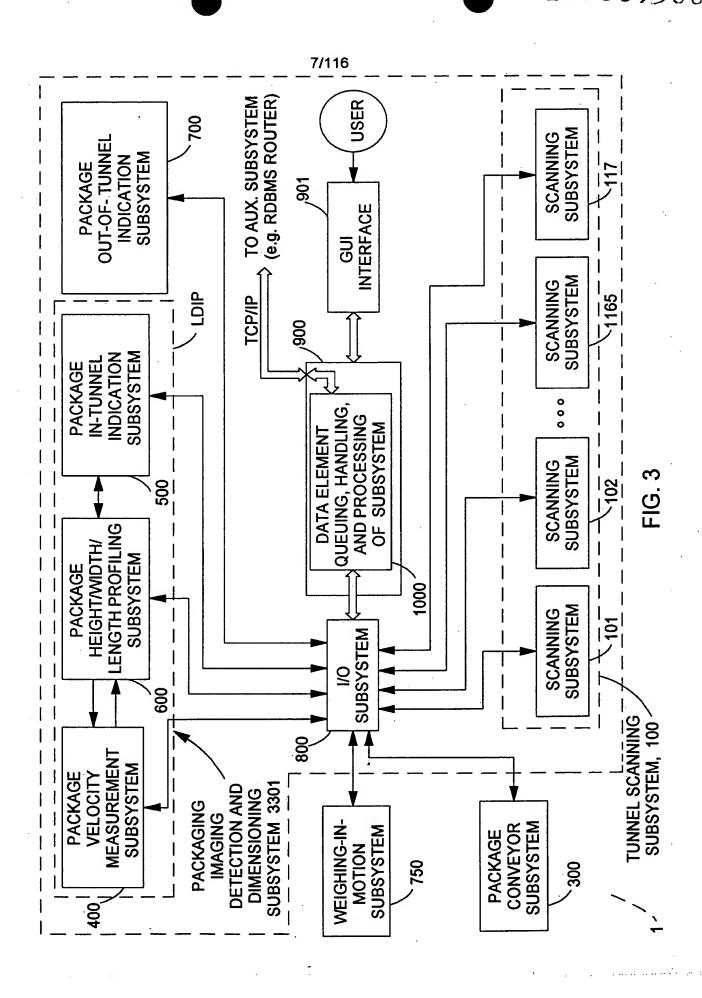


FIG. 2B



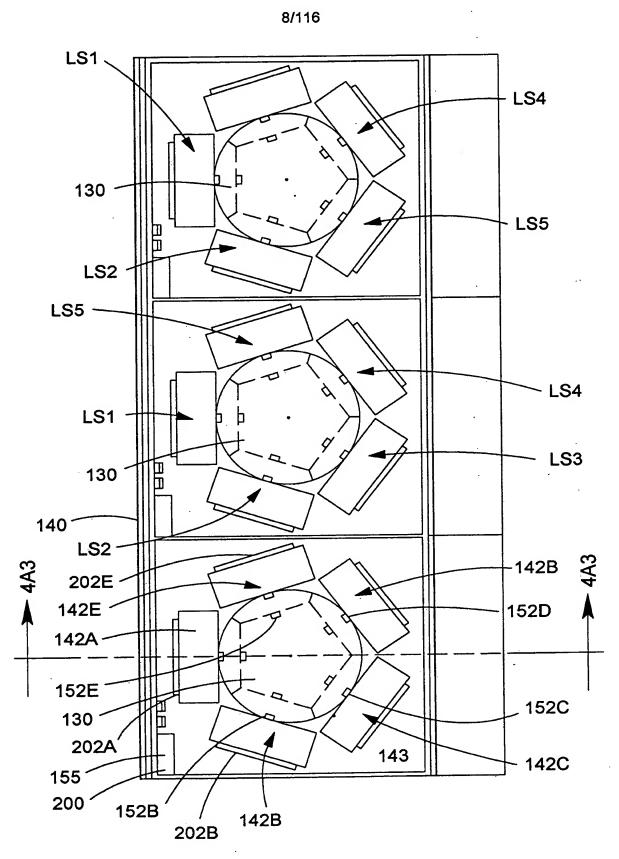


FIG. 4A1

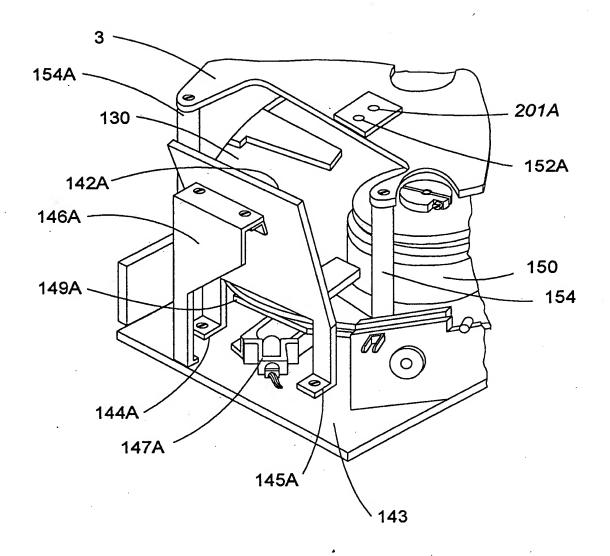


FIG. 4A2

10/116

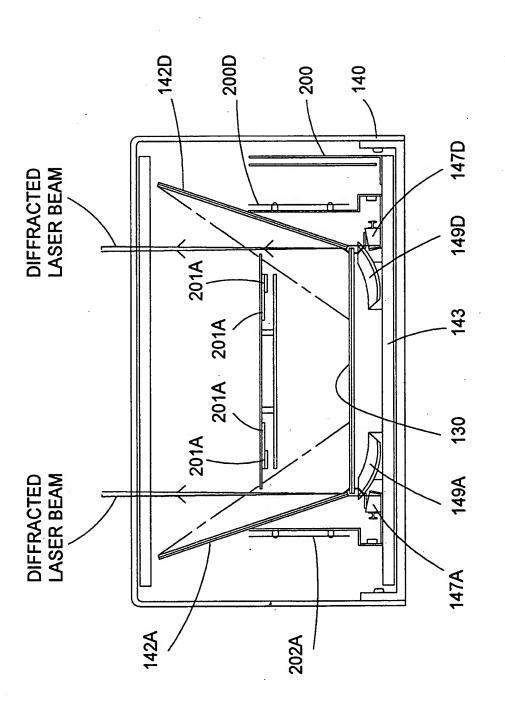


FIG. 4A3

11/116

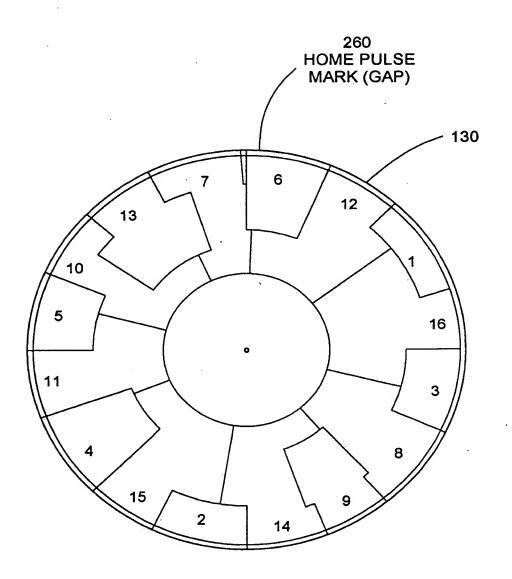
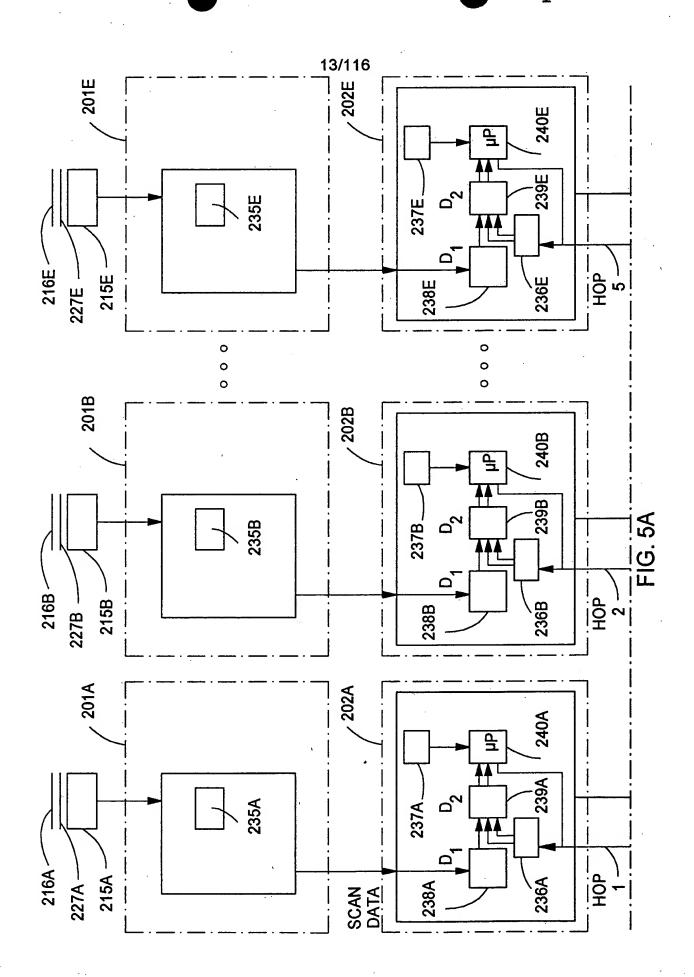
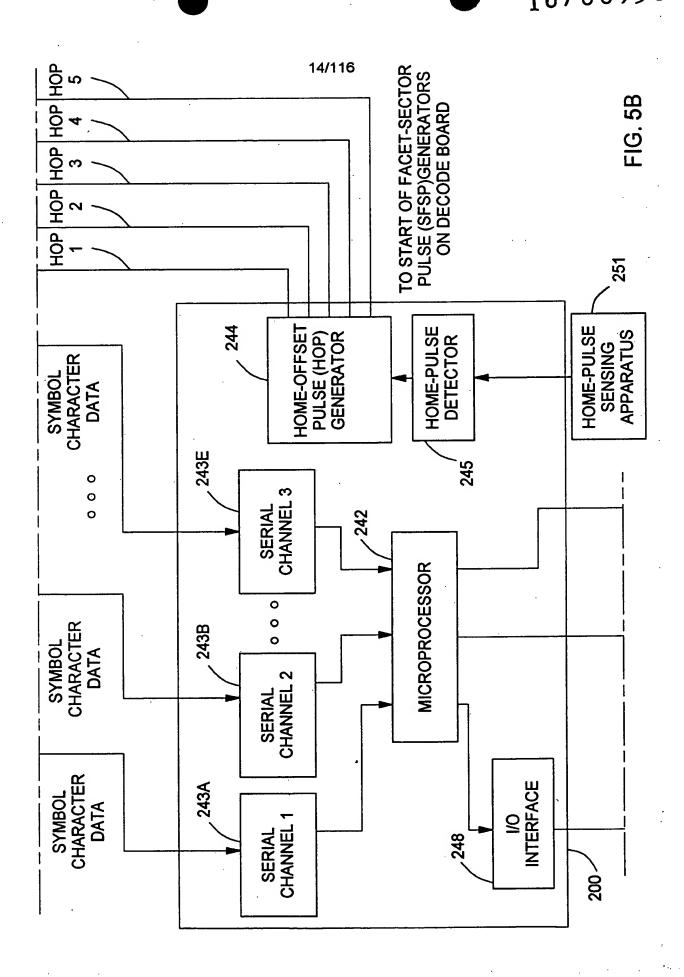


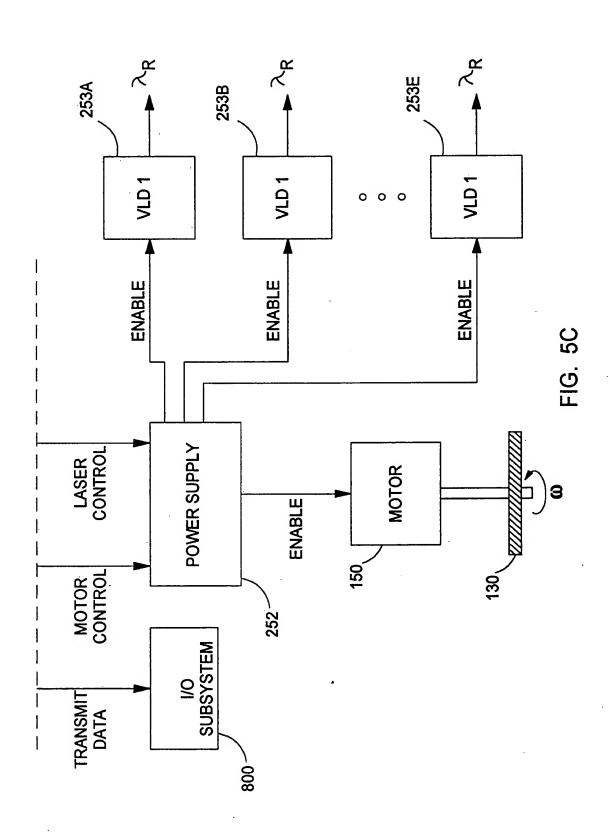
FIG. 4A4

					1	12/	116	3								
ROTATION ANGLE (DEGREES)	23.51	22.10	20.77	19.52	23.51	22.10	20.77	19.52	55.73	55.73	55.73	55.73	55.89	55.89	55.89	55.89
SCAN MULT. ROTATION FACTOR ANGLE (m) (DEGREES	1.26	1.34	1.41	1.48	1.26	1.34	1.41	1.48	1.25	1.32	1.39	1.44	1.25	1.32	1.39	1.44
SCAN ANGLE (DEGREES)	29.61	29.62	29.39	28.92	29.61	29.62	29.39	28.92	25.01	25.02	24.88	24.59	25.01	25.02	24.88	24.59
ANGLE OF BEAM FROM VERTICAL (DEGREES)	-3.06	2.38	7.77	13.03	-3.06	2.38	7.77	13.03	-2.56	2.00	6.53	10.99	-2.56	2.00	6.53	10.99
ANGLE OF DIFFRACTION (DEGREES)	28.94	34.38	39.77	45.03	28.94	34.38	39.77	45.03	29.44	34.00	38.53	42.99	29.44	34.00	38.53	42.99
ANGLE B (DEGREE)	61.06	55.62	50.23	44.97	61.06	55.62	50.23	44.97	60.56	56.00	51.47	47.01	60.56	56.00	51.47	47.01
ANGLE A (DEGREE)	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9
GEOMETRICAL FOCAL LENGTH (INCHES)	49.76	49.73	50.16	51.01	49.76	49.73	50.16	51.01	59.38	59.36	59.72	60.44	59.38	59.36	59.72	60.44
ACETFOCAL LENGTH (INCHES)	49.57	49.54	49.96	50.81	49.57	49.54	49.96	50.81	59.06	59.04	59.39	60.10	29.06	59.04	59.39	60.10
ACET	-	. 2	က	4	· rc		· ~	- ∞	о	10	: =	: 2	<u> </u>	4	15	9





15/116



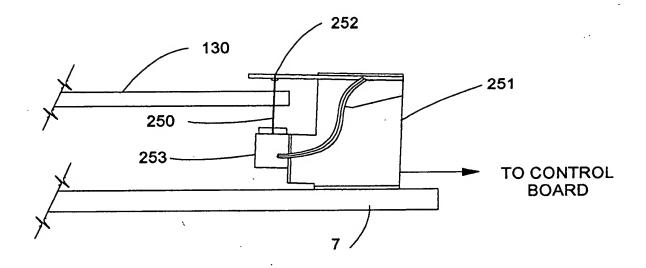


FIG. 6A

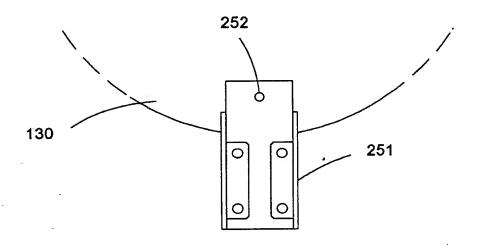
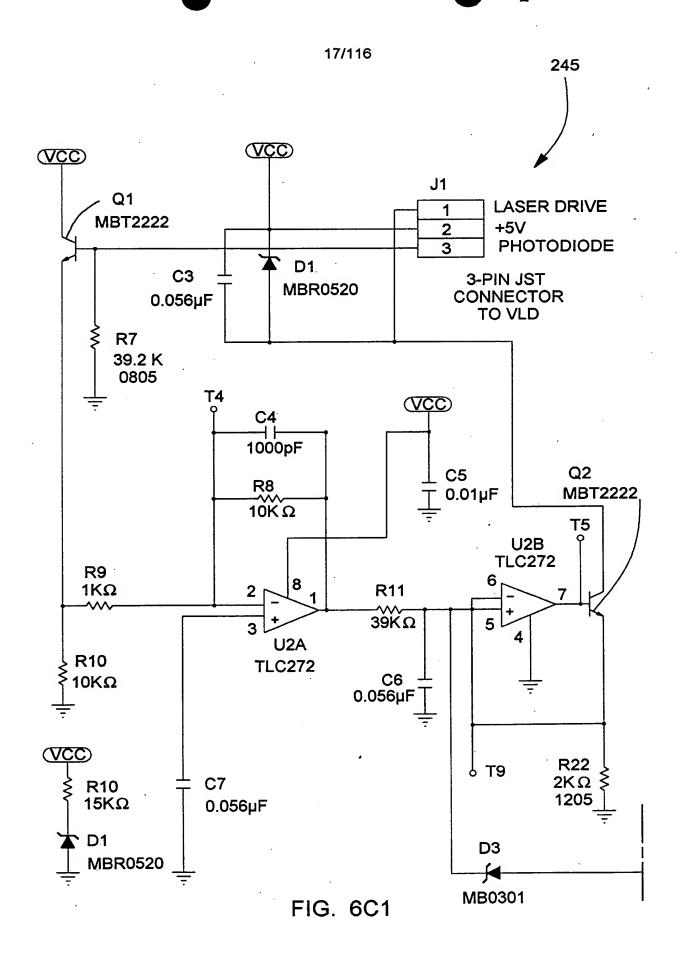


FIG. 6B



18/116

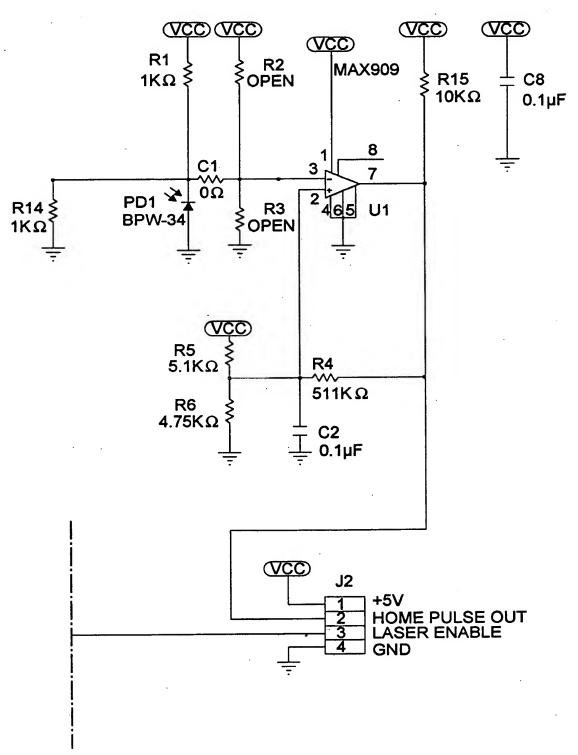


FIG. 6C2

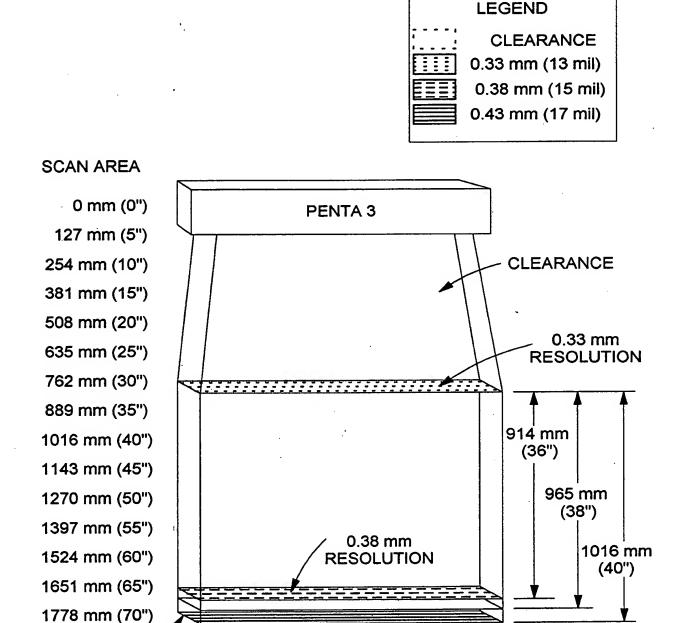
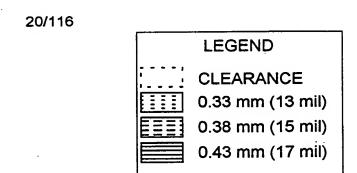


FIG. 7A

¹ 0.43 mm RESOLUTION 1219 mm (48")



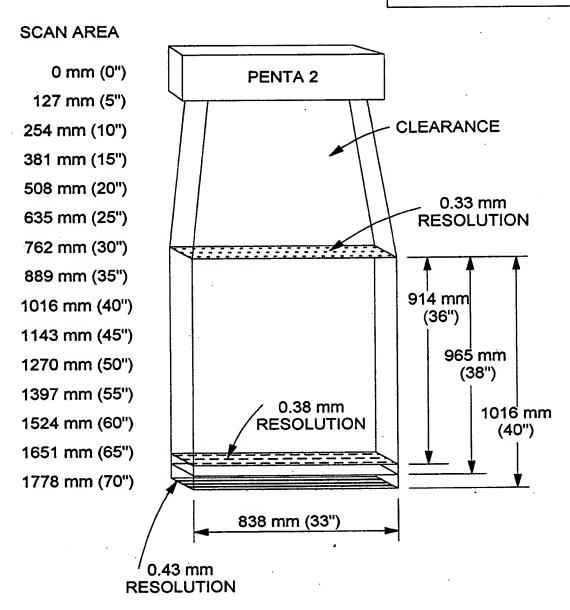
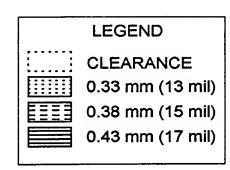


FIG. 7B



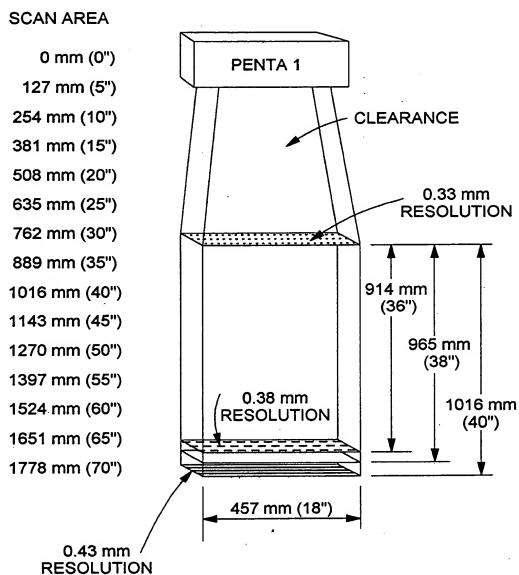


FIG. 7C

SPECIFICATIONS FOR PENTA 1, PENTA 2, PENTA 3 SCANNERS

OPERATIONAL

LIGHT SOURCE 5 VISIBLE LASER DIODES 858 + 5mm

LASER POWER 8.4mW (PEAK): LESS THAN 1 mW AVERAGE POWER

DEPTH OF

914mm (36") FOR 0.33 mm (13mil) BAR CODES

SCAN FIELD

965mm (38") FOR 0.38 mm (15mil) BAR CODES

1,016mm (40") FOR 0.43 mm (17mil) BAR CODES

WIDTH OF SCAN FIELD PENTA 1: 457mm (18")

PENTA 2: 838mm (33")

PENTA 3: 1219mm (48")

SCAN SPEED

PENTA 1: 6.930 SCAN LINES PER SECOND

PENTA 2: 13,860 SCAN LINES PER SECOND

PENTA 3: 20,790 SCAN LINES PER SECOND

SCAN PATTERN OMNIDIRECTIONAL 5-SIDED PENTAGON SCAN

PATTERN

PENTA 1: 20 SCAN LINES REPEATED AT FOUR

DISTANCES (80 TOTAL)

PENTA 2: 40 SCAN LINES REPEATED AT FOUR

DISTANCES (160 TOTAL)

PENTA 3: 60 SCAN LINES REPEATED AT FOUR

DISTANCES (240 TOTAL)

MINIMUM BAR

0.33 mm (13mil)

WIDTH

DECODE CAPABILITY AUTODISCRIMINATES ALL STANDARD BAR CODES

SYSTEM

RS 232. POINT TO POINT. RS422. LIGHT PEN

INTERFACES

EMULATION

PRINT

35% MINIMUM REFLECTANCE DIFFERENCE

CONTRAST

NUMBER CHARACTERS

UP TO 60 DATA CHARACTERS. (MAXIMUM NUMBER WILL VARY BASED ON SYMBOLOGY AND DENSITY)

READ

ASPECT RATIO UP TO 2.6 TO 1

FIG. 8

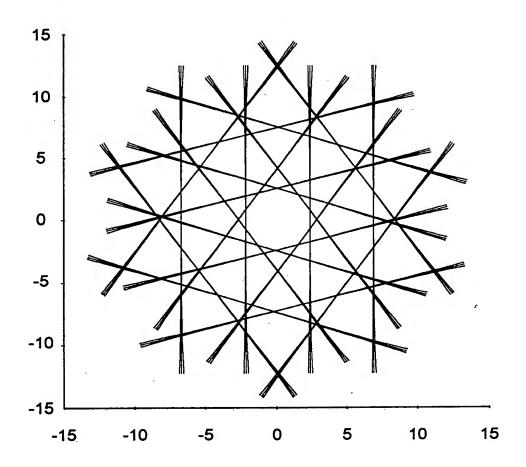
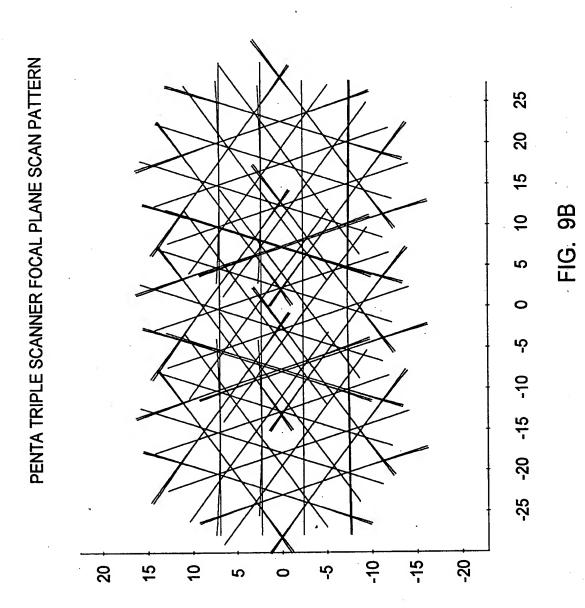
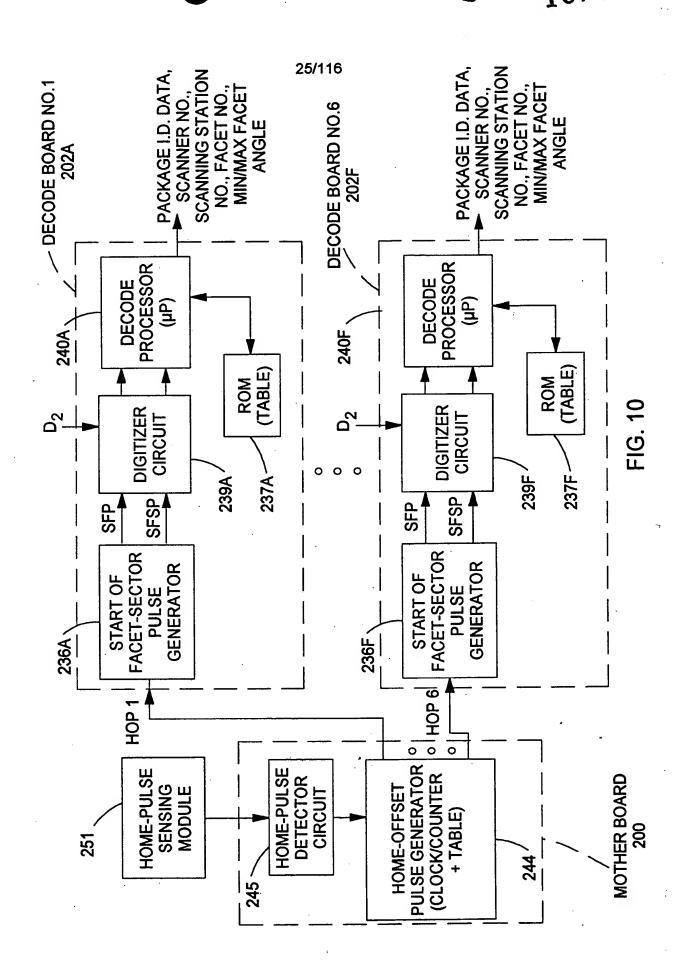


FIG. 9A





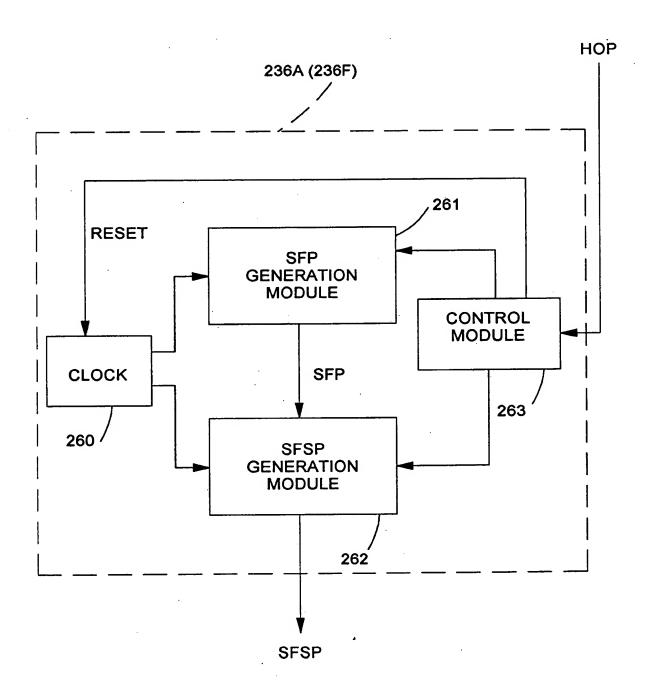


FIG. 10A

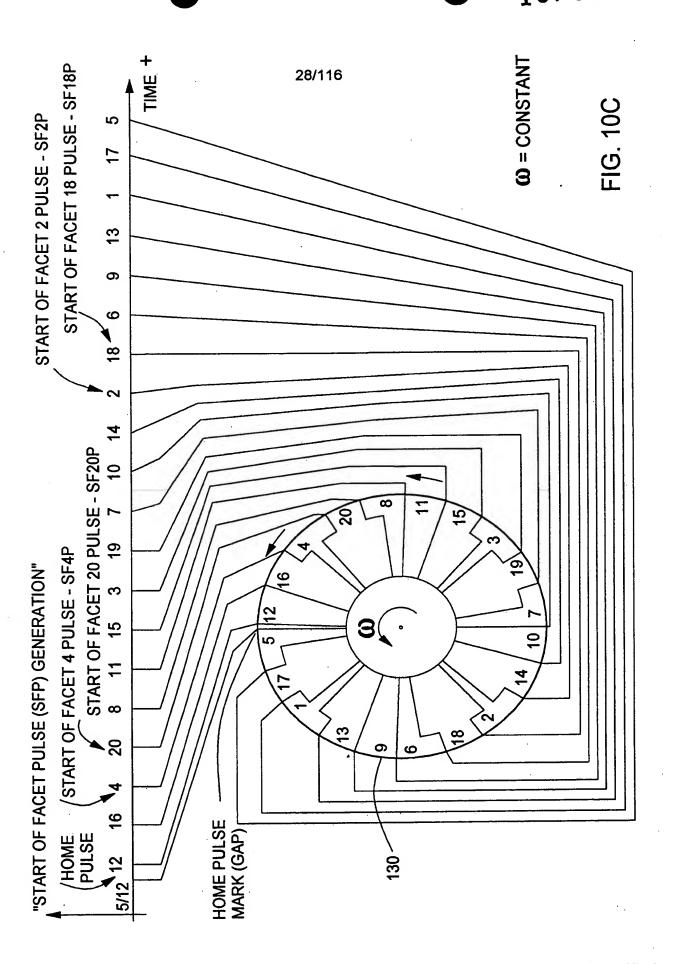
27/116

DATA TABLE EMBODIED IN SFP GENERATOR ON DECODE PROCESSOR BOARD

	TRIGGERING EVENT WHEN THE CLOCK PULSE COUNT ATTAINS THE VALUE EQUAL TO THE COUNT VALUE SET FORTH BELOW	PULSE EVENT FROM
İ	TO THE COURT VALUE SETT ON THE BELOW	SFP MODULE
12	7	SF12P
16	146	SF16P
4	271	SF4P
20	4467	SF20P
8	561	SF8P
11	716	SF11P
15	855	SF15P
3	980	SF3P
19	1155	SF19P
7	1270	SF7P
10	1425	SF10P
14	1564	SF14P
2	1689	SF2P
18	1864	SF18P
6	1979	SF6P
9	2134	SF9P
13	2273	SF13P
1	2398	SF1P
17	2573	SF17P
5	2688	SF5P

W = 5200 RPM CLOCK PULSE WIDTH = 4 μSEC

FIG. 10B



29/116

TABLE EMBODIED IN SFSP GENERATOR DECODE PROCESSOR BOARD

SCANNING FACET NO.	SFSP TRIGGERING EVENT	PULSE EVENT FROM SFSP MODULE.					
12	RULES 1 - 4 IN FIGS.	SFSP 12/1P SFSP 12/2P SFSP 12/3P SFSP 12/4P					
16	RULES 1 - 4 IN FIGS.	SFSP 16/1P SFSP 16/2P SFSP 16/3P SFSP 16/4P					
4	RULES 1 - 4 IN FIGS.	SFSP 4/1P SFSP 4/2P SFSP 4/3P SFSP 4/4P					
20	RULES 1 - 4 IN FIGS.	SFSP 20/1P SFSP 20/2P SFSP 20/3P SFSP 20/4P					
8	RULES 1 - 4 IN FIGS.	SFSP 8/1P SFSP 8/2P SFSP 8/3P SFSP 8/4P					
11	RULES 1 - 4 IN FIGS.	SFSP 11/1P SFSP 11/2P SFSP 11/3P SFSP 11/4P					
o · · · · · · · · · · · · · · · · · · ·							
17	RULES 1 - 4 IN FIGS.	SFSP 17/1P SFSP 17/2P SFSP 17/3P SFSP 17/4P					
5	RULES 1 - 4 IN FIGS.	SFSP 5/1P SFSP 5/2P SFSP 5/3P SFSP 5/4P					

RULE 1: FOR GENERATING SFSP/1P TYPE PULSES

FOR EACH FACET X BEFORE WHICH IS LOCATED FACET X-1 AND BEYOND WHICH IS LOCATED FACET X+1 (ABOUT THE SCANNING DISC), THE SFSP GENERATION MODULE GENERATES SFSX/1P TYPE PULSES WHEN THE COUNT IS EQUAL TO:

COUNT (SFSP)

RULE 2: FOR GENERATING SFSX/2P TYPE PULSES

FOR EACH FACET X BEFORE WHICH IS LOCATED FACET X-1 AND BEYOND WHICH IS LOCATED FACET X+1 (ABOUT THE SCANNING DISC), THE SFSP GENERATION MODULE GENERATES SFSX/2P TYPE PULSES WHEN THE COUNT IS EQUAL TO:

COUNT (SFSP) +1
$$\frac{\text{COUNT (SFX+1P) - COUNT (SFXP)}}{4}$$

RULE 3: FOR GENERATING SFSP/3P TYPE PULSES

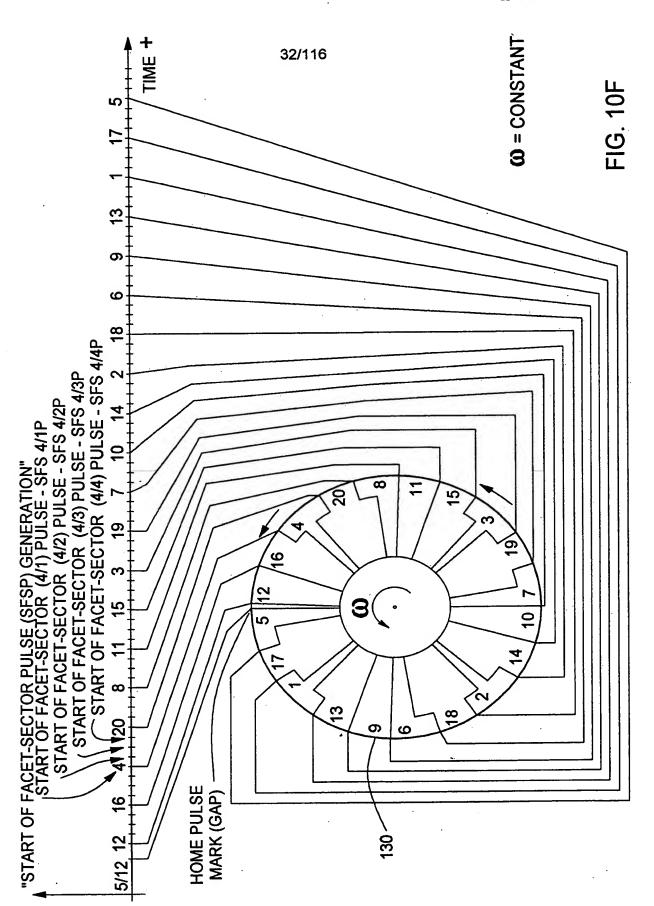
FOR EACH FACET X BEFORE WHICH IS LOCATED FACET X-1 AND BEYOND WHICH IS LOCATED FACET X+1 (ABOUT THE SCANNING DISC), THE SFSP GENERATION MODULE GENERATES

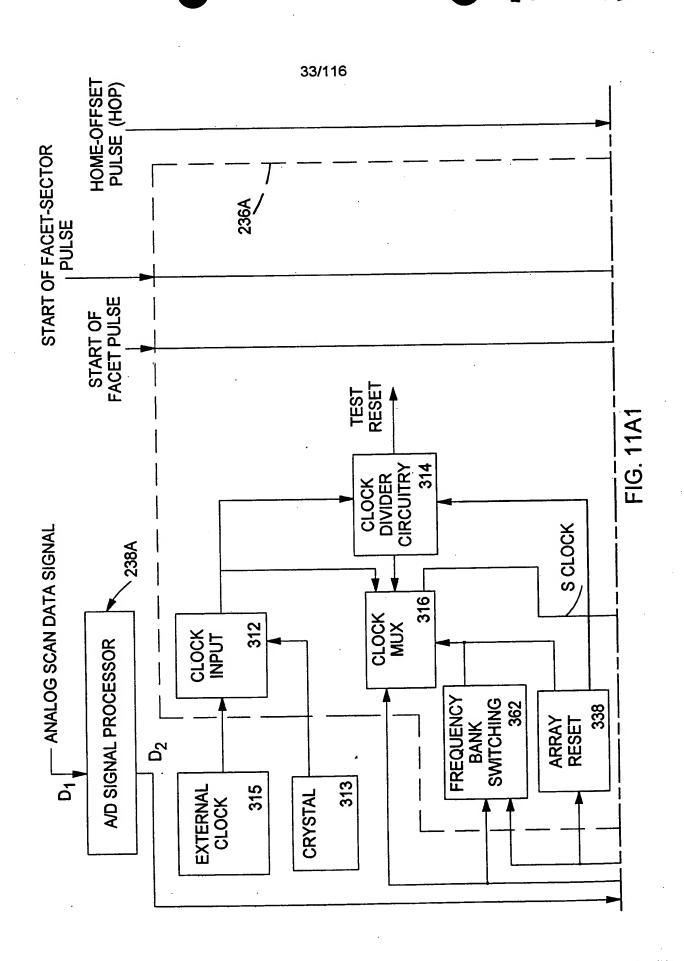
SFSX/3 TYPE PULSES WHEN THE COUNT IS EQUAL TO:

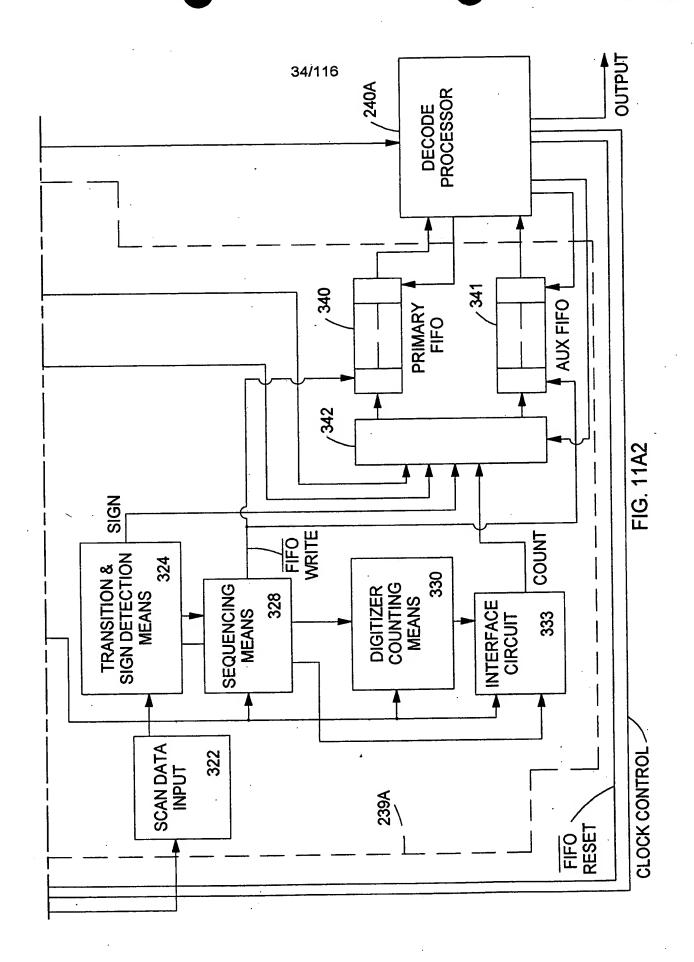
COUNT (SFSP) +2
$$\frac{\text{COUNT (SFX+1P) - COUNT (SFXP)}}{4}$$

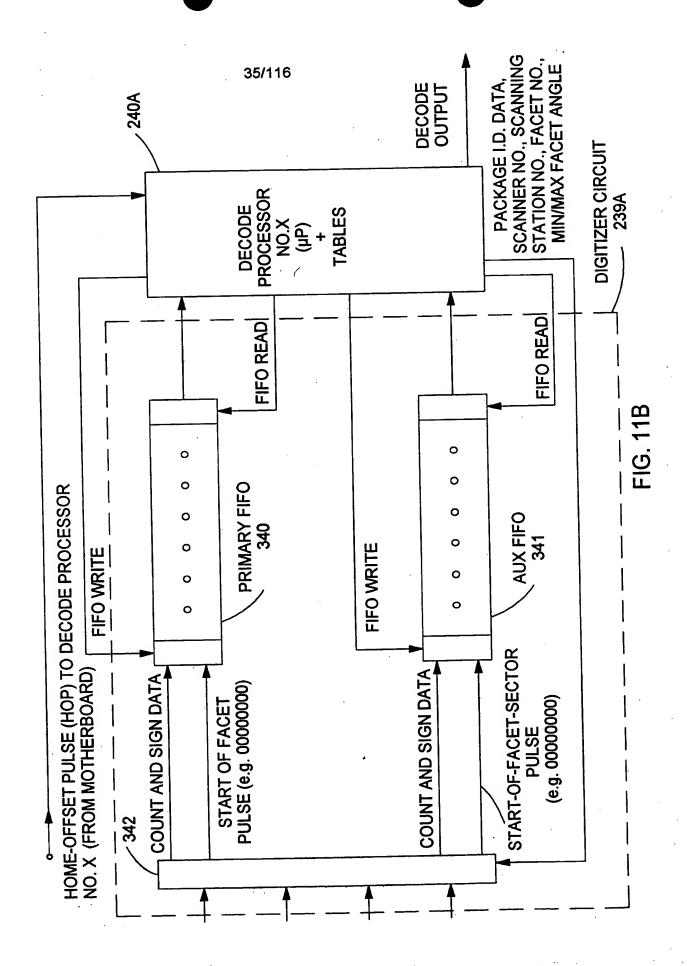
RULE4: FOR GENERATING SFSX/4P TYPE PULSES

FOR EACH FACET X BEFORE WHICH IS LOCATED FACET X-1 AND BEYOND WHICH IS LOCATED FACET X+1 (ABOUT THE SCANNING DISC), THE SFSP GENERATION MODULE GENERATES SFSX/4 TYPE PULSES WHEN THE COUNT IS EQUAL TO:









36/116

SCANNER NO.	TOTAL NO. OF FACETS ON DISC
NO. OF SECTORS / FACET	SCANNING STATION NO.

FIG. 11C1

SCANNING FACET NO.	TRIGGERING EVENT WHEN THE CLOCK PULSE COUNT ATTAINS THE VALUE EQUAL TO THE COUNT VALUE SET FORTH BELOW	PULSE EVENT FROM SFP MODULE
12	7	SF12P
16	146	SF16P
4	271	SF4P
20	4467	SF20P
8	561	SF8P
11	716	SF11P
15	855	SF15P
3	980	SF3P
19	1155	SF19P
7	1270	SF7P
10	1425	SF10P
14	1564	SF14P
2	1689	SF2P
18	1864	SF18P
6	1979	SF6P
9	2134	SF9P
13	2273 ·	SF13P
1	2398	SF1P
17	2573	SF17P
5	2688	SF5P

TABLES EMBODIED IN DECODE PROCESSOR CLOCK PULSE WIDTH = 4 µSEC W = 5200 RPM

FIG. 11C2

10009369009368

MINIMUM AND

37/116 TABLE EMBODIED IN DECODE PROCESSOR

MAXIMUM FACET ANGLES. CORRESPONDING TO SFS **PULSE EVENT** FACET-SECTOR SCANNING TRIGGERING FROM SFSP IDENTIFIED FACET NO. **EVENT** MODULE. BY SFSP EVENT PROT MIN, PROT MAX SFSP 12/1P SFSP 12/2P RULES 1 - 4 IN FIGS. 12 **SFSP 12/3P** SFSP 12/4P SFSP 16/1P SFSP 16/2P RULES 1 - 4 IN FIGS. 16 SFSP 16/3P SFSP 16/4P SFSP 4/1P SFSP 4/2P RULES 1 - 4 IN FIGS. 4 SFSP 4/3P SFSP 4/4P SFSP 20/1P SFSP 20/2P RULES 1 - 4 IN FIGS. 20 SFSP 20/3P SFSP 20/4P SFSP 8/1P SFSP 8/2P RULES 1 - 4 IN FIGS. 8 SFSP 8/3P SFSP 8/4P SFSP 11/1P SFSP 11/2P 11 RULES 1 - 4 IN FIGS. **SFSP 11/3P** SFSP 11/4P 0 0 SFSP 17/1P SFSP 17/2P RULES 1 - 4 IN FIGS. 17 SFSP 17/3P SFSP 17/4P SFSP 5/1P SFSP 5/2P RULES 1 - 4 IN FIGS. 5 SFSP 5/3P SFSP 5/4P

FIG. 11D

READ SCAN DATA ELEMENTS OUT OF PRIMARY AND AUXILLARY FIFOS IN DIGITIZING CIRCUIT

RECOVER DIGITAL COUNT DATA AND SFSP MARKERS FROM OUTPUT DATA STREAM AND BUFFER SAME

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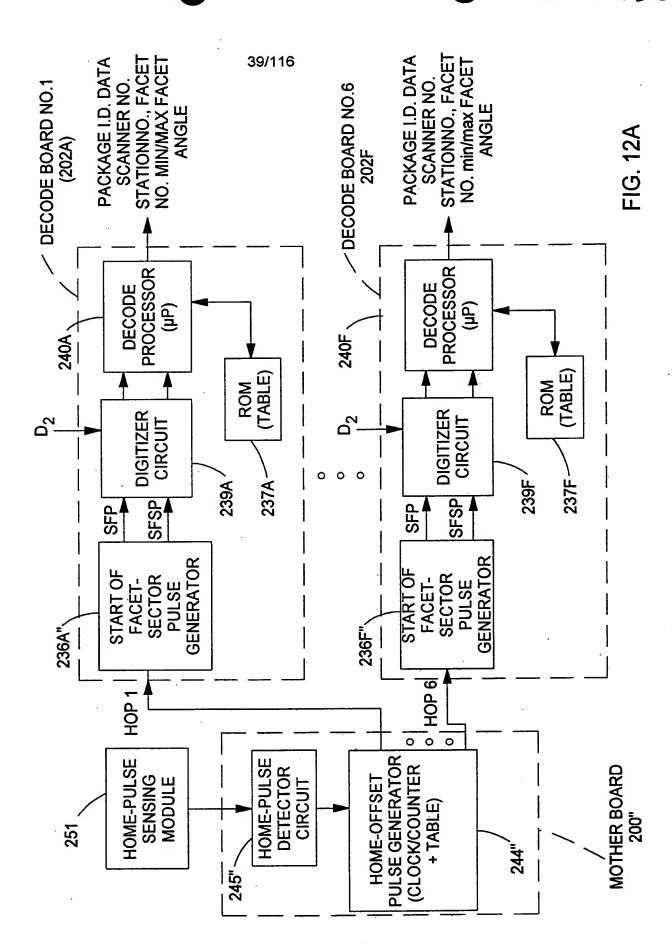
PROCESS DIGITAL COUNT DATA TO DECODE SYMBOL CHARACTERS AND PRODUCE PACKAGE I,D. DATA, AND USE SFSP TABLE TO DETERMINE SYNCHRONOUS MIN/MAX FACET ANGLES OF FACET SECTOR ON SCANNING DISC USED TO GENERATE LASER BEAM (SWEEP) SECTOR THAT COLLECTED THE PACKAGED I.D. DATA

USE DATA TABLE TO CORRELATE PACKAGE I.D. DATA, SCANNER NO., SCANNING STATION NO., FACET NO., AND MIN/MAX FACET ANGLES OF THE FACET SECTOR

D

PRODUCE AS OUTPUT: PACKAGE I.D. DATA, SCANNER NO., SCANNING STATION NO., FACET NO., AND MIN/MAX FACET ANGLES OF THE FACET SECTOR USED TO GENERATE LASER SCANNING PLANE THAT COLLECTED PACKAGE I.D. DATA

E



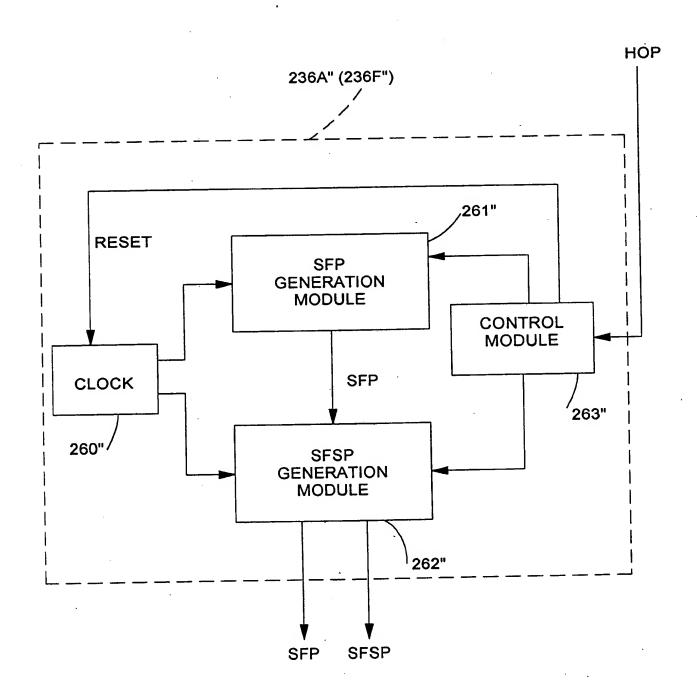
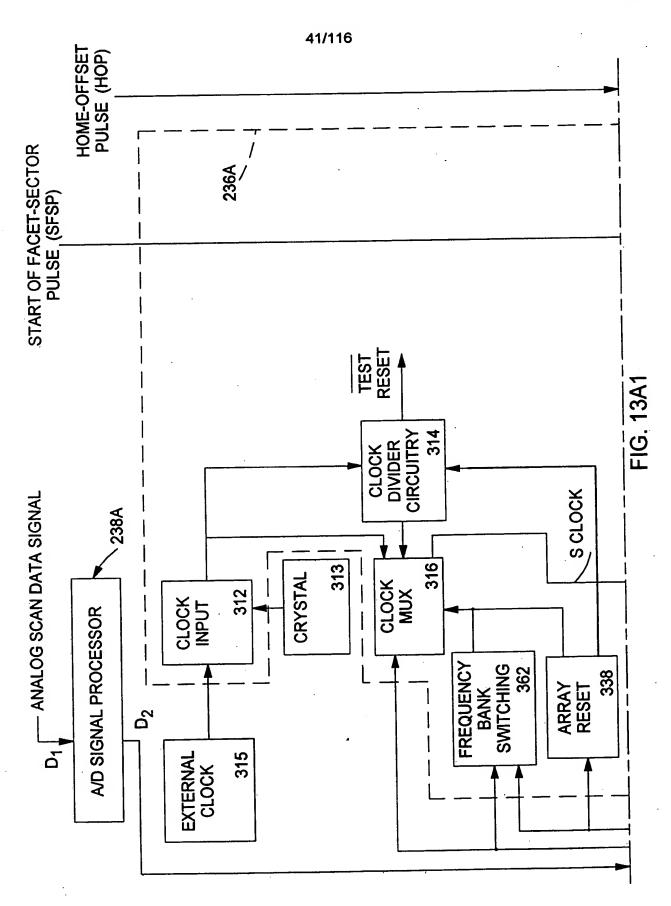
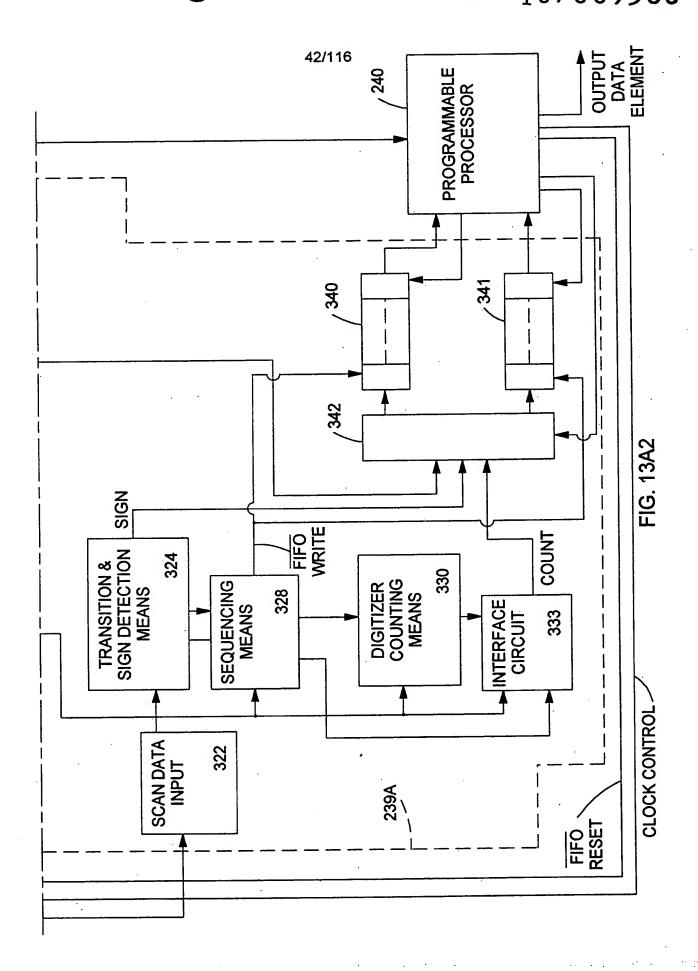
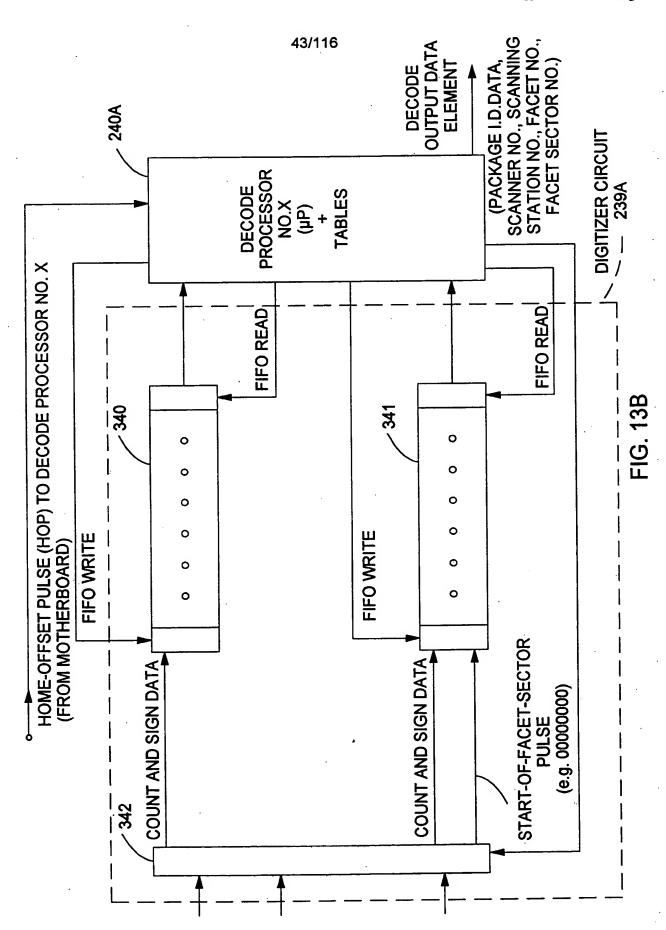


FIG. 12B







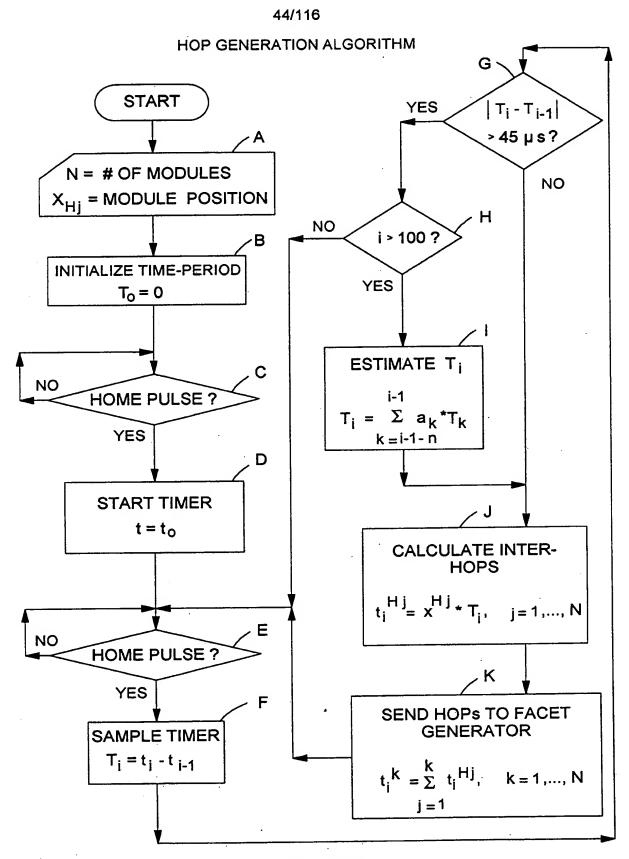


FIG. 14A



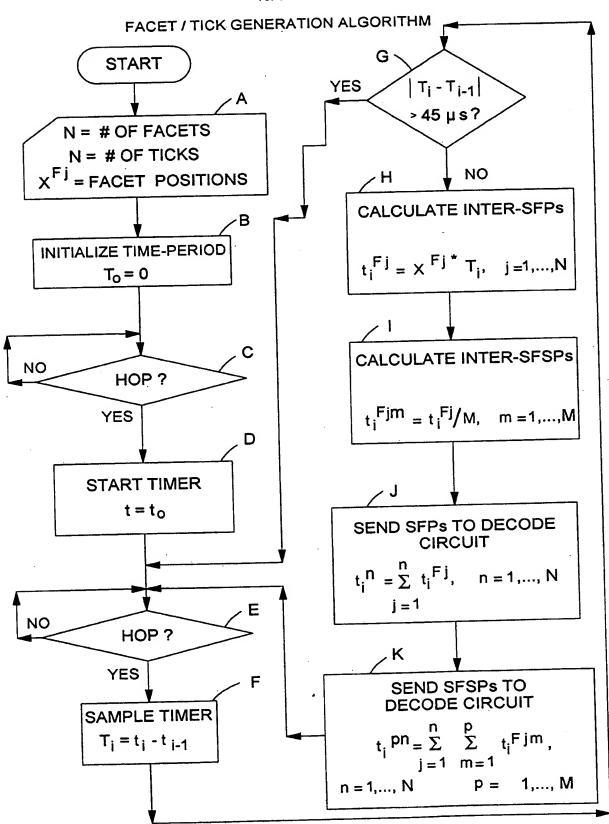
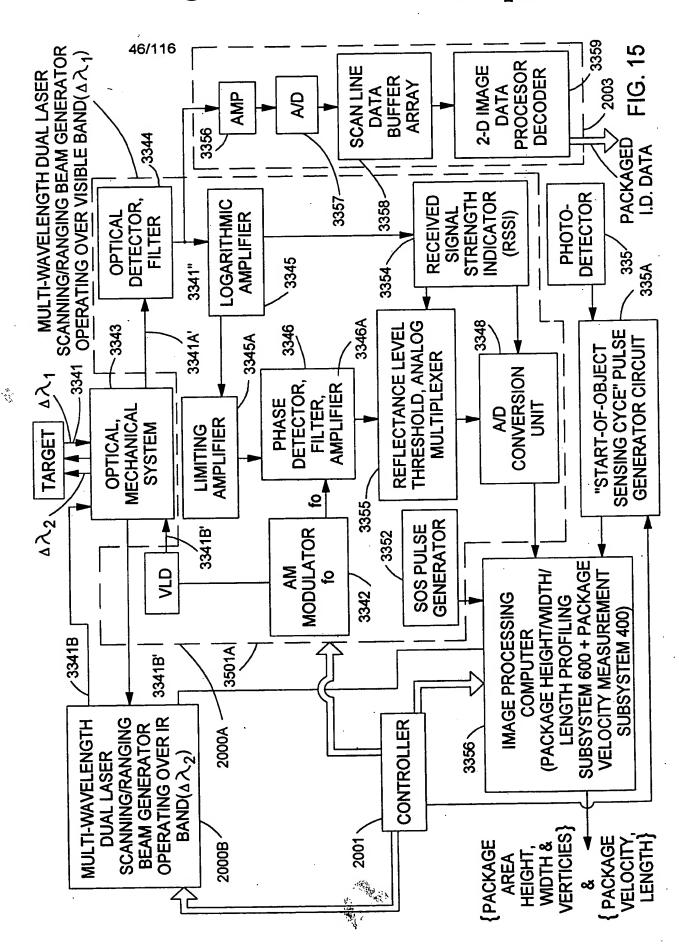


FIG. 14B



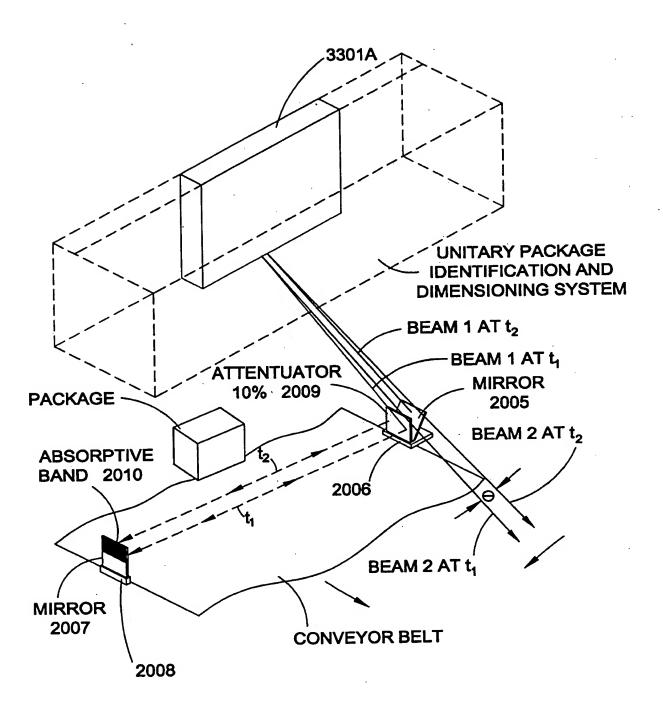


FIG. 15A

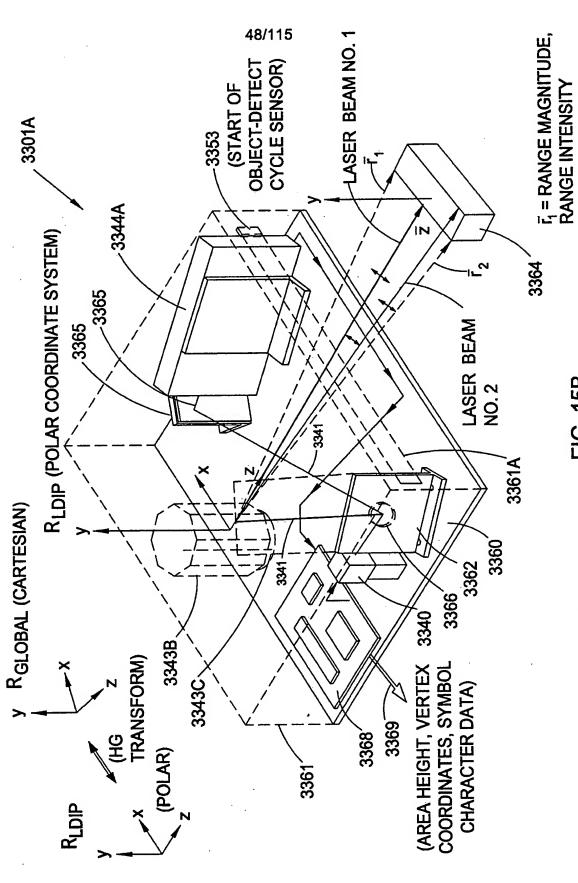


FIG. 15B

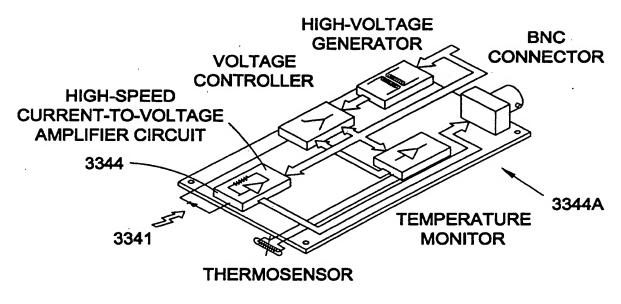


FIG. 15C

R LDIP CARTESIAN

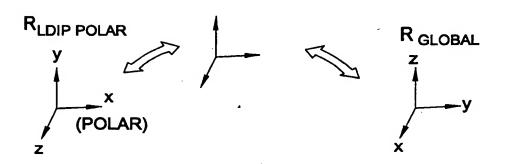


FIG. 15D



50/116

1.046

1.780

1.171

3343B

1.046

2.091

4.046

2.315

3.750°

3.750°

3343B

FACE#	ANGLE (DEGREES)
1	3.75
2	-3 .75
3	3.75
4	-3.75
5	3.75
6	-3.75
7	3.75
8	-3.75

FIG. 15E1

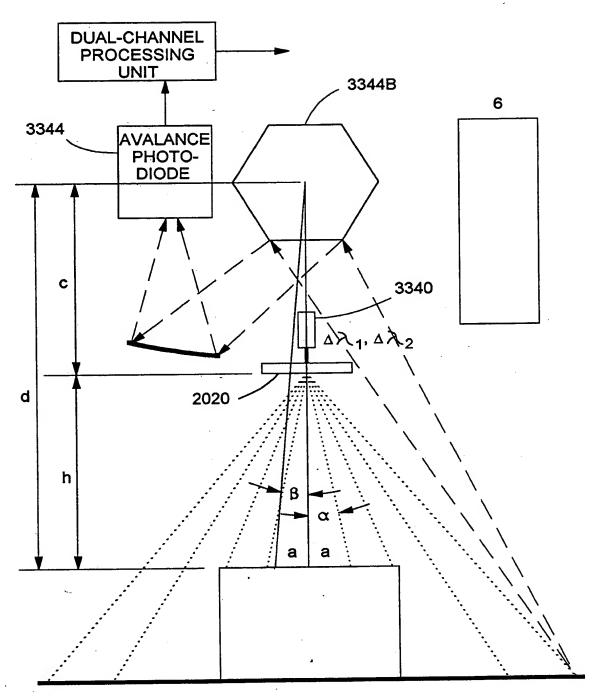
	1	Δλ1
BEAM	3	Δλ ₁ Δλ ₂
NO. 1	5	- 12
	7	
	2	٠, ٨, ٨, ٨,
BEAM	4	Δλ ₁ Δλ ₂
NO. 2	6	
	8	

FIG. 15E2

FIG. 15E3

FIG. 15E4



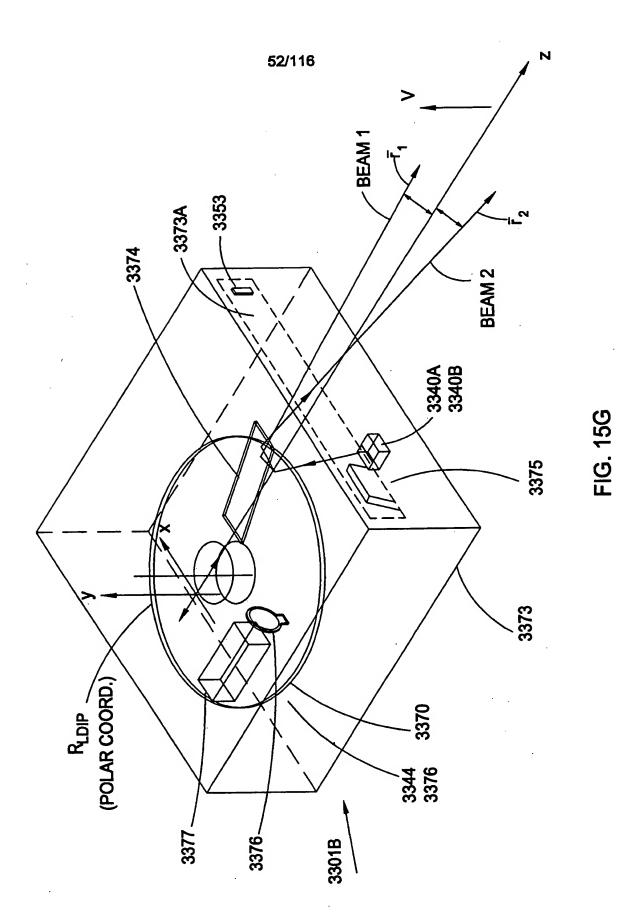


THE EQUATION FOR THE CALCULATION OF THE DISTANCE FROM THE DEVICE TO THE OBJECT:

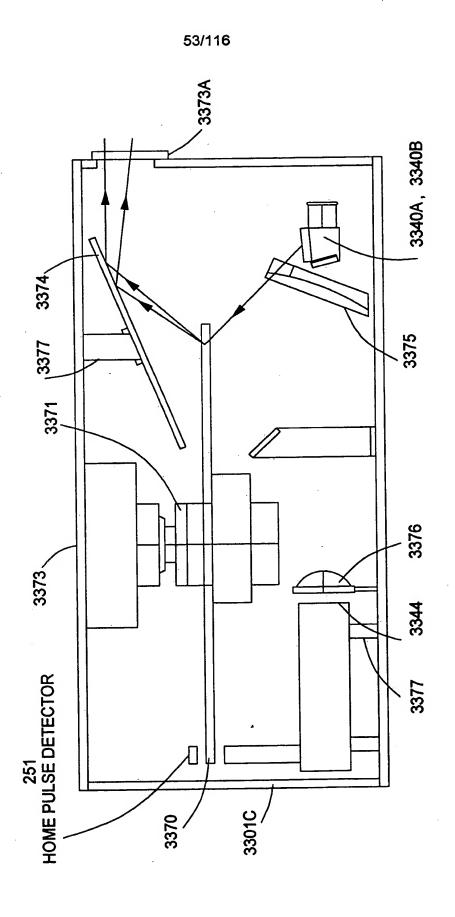
a=h tan α , a=d tan β , d=h-c

h=(c tanβ) (tanα -tanβ)

FIG. 15F







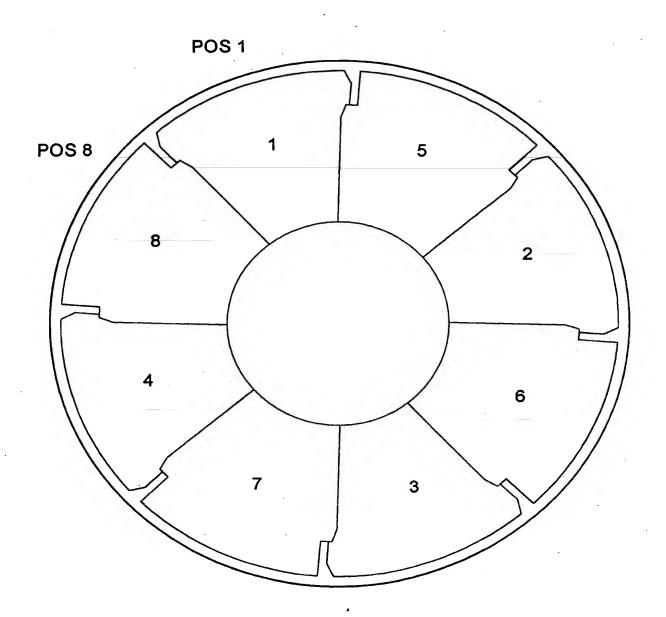


FIG. 151

				SCAN	MULTI.	FACTOR	(E)		1.29	1.29	1.29	1.29	1.36	1.36	1.36	1.36
	nm			SCAN		(DEGREES)			54.93	54.93	54.93	54.93	54.93	54.93	54.93	54.93
	658			ANGLE OF	BEAM FROM	VERTICAL	(DEGREES)	•	5.00	5.00	5.00	5.00	10.00	10.00	10.00	10.00
				ANGLE OF	DIFFRACTION BEAM FROM	(DEGREES)			37.00	37.00	37.00	37.00	42.00	42.00	42.00	42.00
				ANGLE B	(DEGREES)				53.00	53.00	53.00	53.00	48.00	48.00	48.00	48.00
				ANGLEA	(DEGREES) (DEGREES)	Å			45.9	45.9	45.9	45.9	45.9	45.9	45.9	45.9
F DISK (RPM)				GEOMETRICAL	FOCAL	LENGTH	(INCHES)		5000.00	5000.00	5000.00	5000.00	5000.00	5000.00	2000.00	2000.00
				FACET DIFFRACTION GEOMETRICAL	FOCAL	LENGTH	(INCHES)		65.41	65.41	65.41	65.41	65.41	65.41	65.41	65.41
ROTATI				FACET					-		8	4	2	9	7	. 00

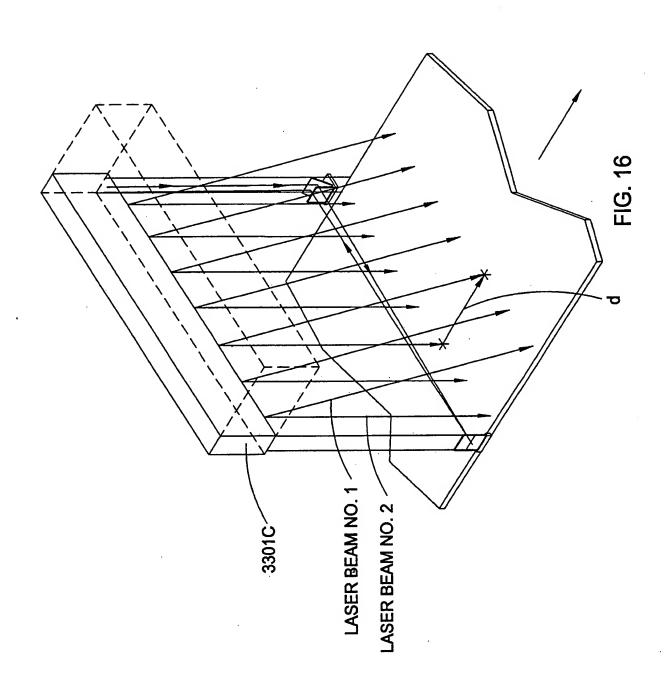
56/1	16

BEAM	SKEW	ANGLE	(DEGREES)						0	0	0	0	0	0	0	0
BEAM	SPEED	AT MIN.	DEPTH	OF	FIELD		(INCHES	(SEC)	41302	41302	41302	41302	43443	43443	43443	43443
BEAM	SPEED	AT MAX.	DEPTH	OF FIELD			(INCHES	/SEC)	51021	51021	51021	51021	53855	53855	53855	53855
BEAM	SPEED	AT	CENTER	OF SCAN OF FIELD	LINE		(INCHES	/SEC)	46251	46251	46251	46251	48649	48649	48649	48649
DESIGN	COLLECTION	AREA	(INCLUDES	NOTCHLOSS	OF 0.15 SQ.	INCHES)			5.30	5.30	5.30	2.30	6.28	6.28	6.28	6.28
MAXMIMUM	COLLECTION	AREA	(IGNORING	NOTCH)		(SQ. IN.)			5.29	5.29	5.29	5.29	6.30	06.3	6.30	6.30
LIGHT	COLLECTION	FACTOR							1.00	1.00	1.00	1.00	1.19	1.19	1.19	1.19
ROTATION ACCOUNTING	FOR DEAD	TIME FOR	LASER BEAM						44.30	44.30	44.30	44.30	41.82	41.82	41.82	41.82
ROTATION	ANGLE	(DEGREES)							42.30	42.30	42.30	42.30	39.82	39.82	39.82	39.82

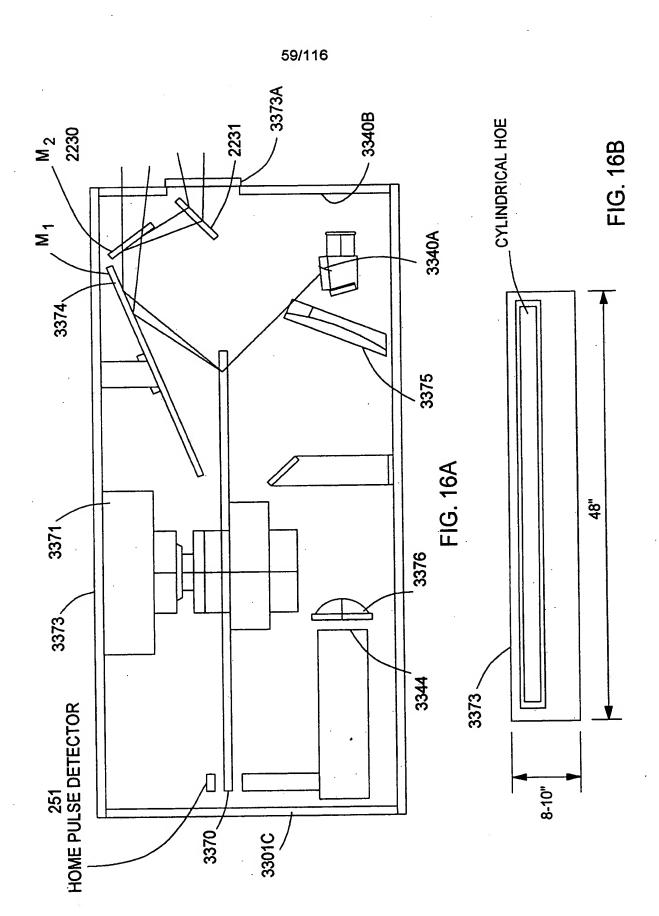
FIG. 15J2

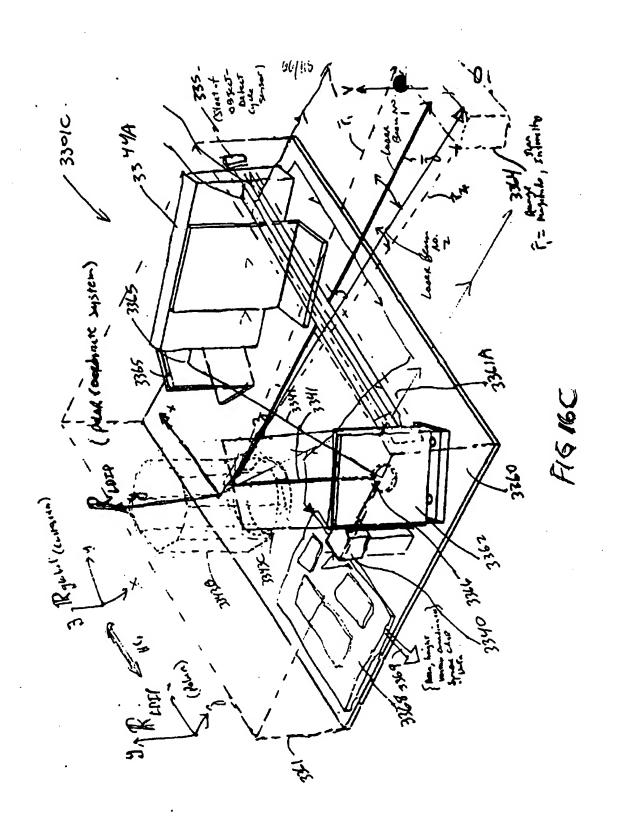
BEAM NO.	FACET NOS.					
	1					
1	2	$\Delta\lambda_1, \Delta\lambda_2$				
	3	4/(1, 4/(2				
	4					
	5	·				
2	6	$\Delta\lambda_1, \Delta\lambda_2$				
	7	2, (1, -, 12				
	8					

58/116



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61/116

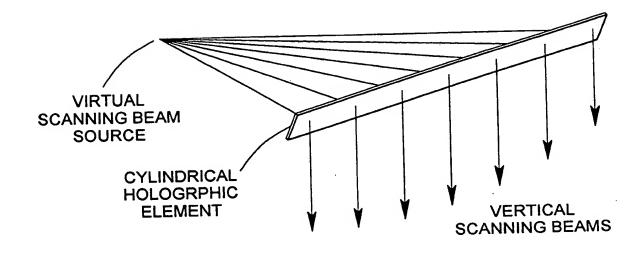


FIG. 16D

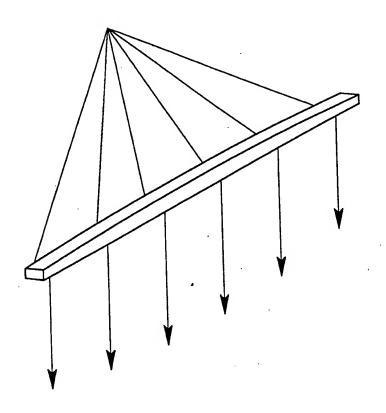
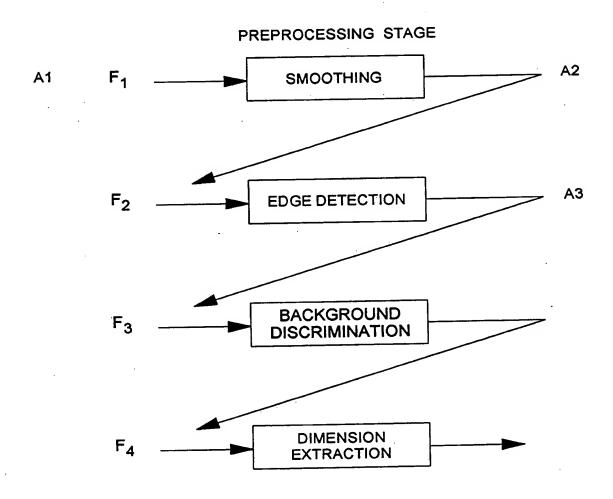


FIG. 16E

62/116

HEIGHT/WIDTH/PROFILING PACKAGE DIMENSIONING SUBSYSTEM

(600) FIGS. 17 - 29B



F₁ = RAW IMAGE

F₂ = SMOOTH IMAGE

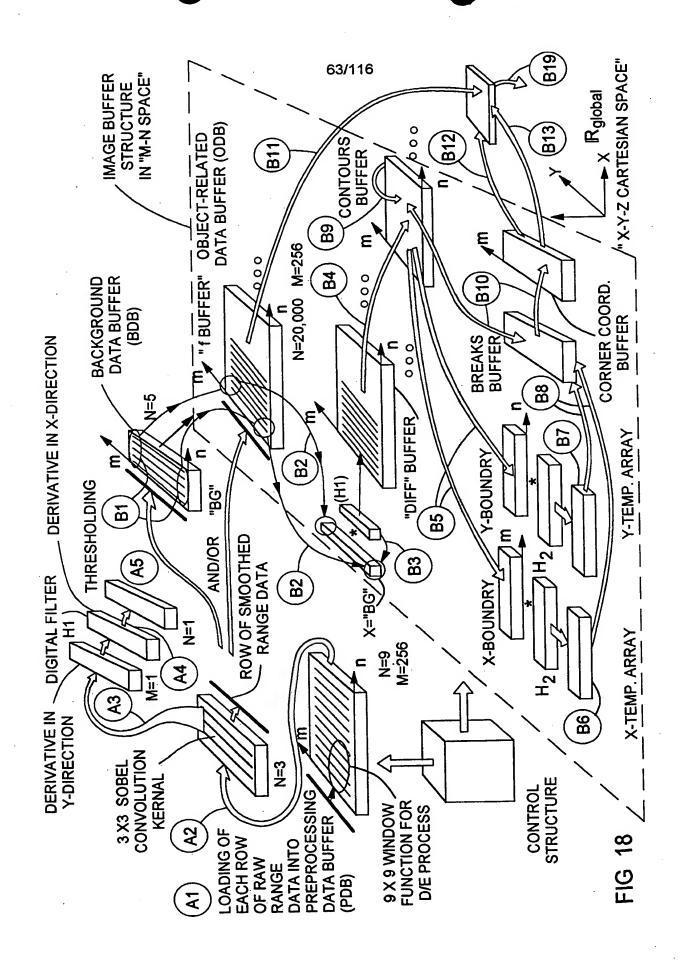
F₃ = EDGE IMAGE

FA = OBJECT IMAGE

F = AREA HEIGHT, AND CORNER COORDINATES

FIG. 17

1u/0093**68**



CONTROL STRUCTURES

```
INPUT OF OPERATOR PARAMETERS AND INITIALIZATIONS
```

```
FORz := 1 TO n DO
    READ ROW Z OF f INTO THE IMAGE ROW STORE
    BUF(1...M, IND (z));
FOR y := k + 1 to N - k DO BEGIN
        FOR x := k + 1 TO M - k DO BEGIN
                FOR z := 1 TO a DO
                          F(z) := BUF(x + xind(z), ind(k + 1 + yind(z))):
```

PROCESSING OF THE PICTURE WINDOW F(f,(x,y)) WITH A SPECIFIC OPERATOR KERNEL ARGUMENTS: F(z), WITH $1 \le z \le a$, OR F(i,j,), WITH $-k \le i, j \le k$

GRAY VALUE v RESULT:

```
\oplus
                 IF (PARSEQ = 0) THEN
                     BUFOUT(x) := v
                 ELSE BUF (x, IND (k+1)) := v
\oplus
                 END(for):
          IF (PARSEQ = 0) THEN
\oplus
                 WRITE ROW BUFFER STORE BUFOUT(1...M) INTO
                 ROW y OF THE RESULTANT IMAGE FILE OUT
\oplus
          ELSE
                 WRITE IMAGE ROW STORE BUF(1...M, IND(K+ 1)) INTO
0
                 ROW y OF THE RESULTANT IMAGE FILE OUT;
\oplus
          IF (y N-k) THEN BEGIN
                 READ ROW y + k + 1 OF THE INPUT IMAGE FILE INTO
                 THE IMAGE ROW STORE BUF(1...M, IND(1));
                 LINK := IND(1);
                 FOR z := 1 TO n - 1 DO IND(z) := IND(z + 1)
                 IND(n) := LINK
                 END (if)
          END (for)
```

CONTROL STRUCTURE FOR THE COMPUTATION OF LOCAL OPERATORS, USING ROW-WISE BUFFERING, THE CENTERED ii-COORDINATE SYSTEM, AND THE SPATIAL ARRANGEMENT FOR THE WINDOW CONTENT IF THE ONE-DIMENSIONAL ARRAY F(z) IS USED. PROGRAM LINES LABLED WITH THE ARE SUPERFLUOUS IF A PARALLEL OPERATOR HAS TO BE IMPLEMENTED

В

65/116

STEP A1 INVOLVES CAPTURING LINES (ROWS) OF DIGITIZED RANGE DATA PRODUCED BY THE LASER SCANNING/RANGING UNIT DURING EACH SWEEP OF THE AMPLITUDE MODULATED LASER BEAM ACROSS THE WIDTH OF THE CONVEYER BELT. EACH ROW OF RAW RANGE DATA HAS A PREDETERMINED NUMBER OF RANGE VALUE SAMPLES (E.G. M=256) TAKEN DURING EACH SCAN ACROSS THE CONVEYOR BELT. EACH SUCH RANGE DATA SAMPLE REPRESENTS THE MAGNITUDE OF THE POSITION VECTOR POINTING TO THE CORRESPONDING SAMPLE SAMPLE POINT ON THE SCANNED PACKAGE, REFERENCED WITH RESPECT TO A POLAR-TYPE COORDINATE SYSTEM SYMBOLICALY EMBEDDED WITHIN THE LADAR-BASED IMAGING AND DIMENSIONING SUBSYSTEM. STEP A1 ALSO INVOLVES LOADING A PREDETERMINED NUMBER OFRAW RANGE DATA SAMPLES INTO A FIFO-TYPE PREPROCESSING DATA BUFFER (e.g. M=9) FOR BUFFERING 9 ROWS OF RANGE DATA AT ANY INSTANT OF TIME.

STEP A2 INVOLVES USING, AT EACH PROCESSING CYCLE AND SYNCHRONIZED WITH THE CAPTURE OF EACH NEW ROW OF RAW RANGE DATA, A 2-D (9X9) WINDOW FUNCTION EMBEDDED INTO A GENERAL CONTROL STRUCTURE (e.g. PIXEL PROGRAM LOOP), TO SMOOTH EACH LINE (OR ROW) OF RAW RANGE DATA BUFFERED IN THE PROCESSING DATA BUFFER USING DILUTION AND EROSION (D/E) PROCESS BASED ON NON-LINEAR TYPE MIN/MAX METHODS. THE OUTPUT FROM THIS NON-LINEAR OPERATION IS A SINGLE ROW OF SMOOTH RANGE DATA OF LENGTH M=256 WHICH IS INPUT TO A THREE ROW FIFO BUFFER, AS SHOWN IN FIG. 44G.

STEP 3A INVOLVES USING, AT EACH PROCESSING CYCLE, A 2-D (3X3) CONVOLUTION KERNEL BASED ON THE SOBEL OPERATOR, AND EMBEDDED INTO A GENERAL CONTROL STRUCTURE (e.g. PIXEL PROGRAM LOOP), TO EDGE-DETECT EACH BUFFERED ROW OF SMOOTH EDGE DATA OF LENGTH M=256 WHICH IS INPUT TO A FIRST ONE ROW (N=1) FIFO BUFFER AS SHOWN IN FIG. 44G. THE OUTPUT ROW OF "EDGE DETECTED" RANGE DATA REPRESENTS THE FIRST SPATIAL DERIVATIVE A OF THE BUFFERED ROWS OF RANGE DATA ALONG THE n DIRECTION OF THE N=9 FIFO (CORRESPONDING TO THE FIRST SPATIAL DERIVITIVE OF THE RANGE DATA CAPTURED ALONG THE Y DIRECTION OF THE CONVEYER BELT.





U

STEP A4 INVOLVES USING, AT EACH PROCESSING CYCLE, A 7-TAP FIR-TYPE DIGITAL FILTER (H1) TO COMPUTE THE FIRST SPATIAL DERIVATIVE OF THE BUFFERED ROW OF EDGE-DETECTED RANGE DATA ALONG THE m DIRECTION OF THE N=9 FIFO (CORRESPONDING TO THE FIRST SPATIAL DERIVATIVE OR THE RANGE DATA CAPTURED ALONG THE x DIRECTION OF THE CONVEYOR BELT). THE OUTPUT OF THIS OPERATION IS STORED IN A SECOND ONE ROW (N=1) FIFO, AS SHOWN IN FIG. 44G.

E

STEP A5 INVOLVES ANALYZING, AT EACH PROCESSING CYCLE, THE EDGE -DETECTED DERIVATIVE STORED IN THE SECOND ONE ROW FIFO IN ORDER TO (1) FIND THE MAXIMUM VALUE THEREOF, AND THEN (2) COMPARE THE MAXIMUM DERIVATIVE VALUE TO A PREDETERMINED THRESHOLD VALUE. IF ANY OF THE MAXIMUM FIRST DERIVATIVE VALUES IS LARGER THAN THE PREDETERMINED THRESHOLD VALUE, THEN THE UNLOADED ROW OF SMOOTHED RANGE DATA (FROM OUTPUT PORT OF THE THREE ROW FIFO) IS LABELLED AS CONTAINING OBJECT DATA, AND IS LOADED INTO THE INPUT PORT OF THE FIFO-TYPE OBJECT-RELATED DATA BUFFER (ODB), ALSO REFERRED TO AS THE "f" BUFFER, FOR FUTURE USE. OTHERWISE, THE UNLOADED ROW OF SMOOTHED RANGE DATA FROM THE THREE ROW FIFO IS LABELED AS CONTAINING BACKGROUND DATA AND IS LOADED INTO THE INPUT PORT OF THE FIFO-TYPE BACKGROUND DATA BUFFER (BDB), AND POSSIBLY THE ODB, FOR FUTURE USE.

F

STEP B1: AT EACH PROCESSING CYCLE, AND FOR EACH COLUMN POSITION IN THE ROWS BACKGROUND DATA IN THE BDB (REFERENCED BY INDEX m), COMPUTE THE "MEDIAN VALUE" BASED ON THE CURRENT ROWS OF BACKGROUND DATA BUFFERED THEREIN.

, G

STEP B2: AT EACH PROCESSING CYCLE, AND FOR EACH ROW OF OBJECT-RELATED DATA IN THE ODB, SUBTRACT THE PRECOMPUTED MEDIAN VALUE (BG) FROM THE CORRESPONDING RANGE VALUE (f=X), TO PRODUCE A DIFFERENCE VALUE (X-BG) FOR EACH OF THE 256 COLUMN POSITIONS IN THE CORRESPONDING ROW OF OBJECT-RELATED DATA BEING BUFFERED IN THE ODB (ALSO INDICATED AS THE "f BUFFER"), THEREBY PRODUCING A VERTICAL FIRST DISCRETE DERIVATIVE THEREOF (HAVING A COLUMN LENGTH M=256).



,Η

STEP B3: AT EACH PROCESSING CYCLE, SMOOTH THE COMPUTED VERTICAL FIRST DISCRETE DERIVATIVE BY CONVOLVING THE SAME WITH A 5-TAP FIR SMOOTHING FILTER AND TRUNCATING THE RESULTANT ROW OF SMOOTHED DISCRETE DERIVATIVE DATA TO LENGTH M=256, AND THEREAFTER LOAD THE ROW OF SMOOTHED DISCRETE DERIVATIVE DATA IN THE "DIFF" (i.e. DERIVATIVE) DATA BUFFER HAVING m=256 COLUMNS AND n=10,000 OR MORE ROWS (AS REQUIRED BY THE COLLECTED RANGE DATA MAP). THE OUTPUT ROW OF DISCRETE DERIVATIVE DATA CONTAINS OBJECT-RELATED DATA ONLY, AND MOST BACKGROUND NOISE WILL BE ELIMINATED.

STEP B4:AT EACH PROCESSING CYCLE, PERFORM A 2-D IMAGE-BASED CONTOUR TRACING OPERATION ON THE DISCRETE DERIVATIVE DATA CURRENTLY BUFFERED IN THE DIFF DATA BUFFER IN ORDER TO PRODUCE AN ARRAY OF m,n CONTOUR POINTS IN M-N SPACE (AND CORRESPONDING TO X,Y CONTOUR POINTS IN X-Y CARTESIAN SPACE) TYPICALLY, THE ARRAY OF CONTOUR POINTS m,n WILL CORRESPOND TO THE SIDES OF THE POLYGONAL OBJECT EMBODIED IN THE ROWS OF OBJECT DATA CURRENTLY BUFFERED WITHIN THE OBJECT DATA BUFFER, AND THE OUTPUT DATA SET PRODUCED FROM THIS STEP OF THE METHOD CONTAINS EXTRANEOUS CORNER POINTS WHICH NEED TO BE REMOVED FROM THE PRODUCED ARRAY OF CONTOUR POINTS.

STEP B5: AT EACH PROCESSING CYCLE, STORE THE m,n INDICES (ASSOCIATED WITH THE CORNER POINTS OF THE TRACED CONTOURS) IN THE x-BOUNDARY AND y-BOUNDARY BUFFERS, RESPECTIVELY. NOTABLY, THE x-BOUNDARY AND y-BOUNDARY BUFFER IS M-256, AND THE LENGTH OF THE y-BOUNDARY BUFFER IS ALSO M=256

_ /k

STEP B6: AT EACH PROCESSING CYCLE, DETECT THE m INDICES ASSOCIATED WITH "CORNER POINTS" IN THE TRACED CONTOURS BY CONVOLVING THE CURRENT DISCRETE DATA SET STORED IN THE x-BOUNDARY BUFFER (OF LENGTH M=256) WITH THE 11-TAP FIRFILTER (i.e. LOW-PASS 1st DIFFERENTIATOR) AND STORING THE RESULTANT DISCRETE m INDICE DATA SET IN THE x-TEMP ARRAY.

(B)

FIG. 20C





STEP B7: AT EACH PROCESSING CYCLE, DETECT THE n INDICES ASSOCIATED WITH THE "CORNER POINTS" IN THE TRACED CONTOURS BY CONVOLVING THE DISCRETE DATA SET STORED IN THE y-BOUNDRY BUFFER (OF LENGTH N) WITH THE 11-TAP FIR FILTER (i.e. LOW-PASS 1st DIFFERENTIATOR) AND THEN STORING THE RESULTANT DISCRETE n INDICE DATA SET IN THE y-TEMP-ARRAY.

M

STEP B8: AT EACH PROCESSING CYCLE, FIND THE "BREAK POINTS" AMONG THE DETECTED CORNER POINTS STORED IN THE x-TEMP - ARRAY AND y-TEMP-ARRAYS, AND BUFFER THE m AND n INDICES ASSOCIATED WITH THESE BREAK POINTS IN THE IN THE BREAKS BUFFER.

Ν

STEP B9: AT EACH PROCESSING CYCLE, PERFORMING LINEAR CURVE FITTING BETWEEN EVERY TWO CONSECUTIVE BREAK POINTS STORED IN THE BREAKS BUFFER, TO PRODUCE A SINGLE LINE REPRESENTATION THEREOF. EACH LINE CONSTITUTES A SIDE OF A POLYGON REPRESENTATION OF THE OBJECT REPRESENTED IN THE RANGE DATA MAP BUFFERED IN THE ODB OR 1 DATA BUFFER. FOR EVERY TWO CONSECTUTIVE SIDES OF THE POLYGON REPRESENTATION, THE INTERSECTION POINT IS DETERMINED, AND DEEMED A CORNER VERTEX OF THE POLYGON.

STEP B10: AT PROCESSING CYCLE, ONCE ALL CORNER COORDINATES (VERTICES) ARE OBTAINED, THE CORNER VERTICES ARE FURTHER REDUCDED USING A SHARP/DULL ANGLE ELIMINATION ALGORITHM AND CLOSE CORNER ELIMINATION OPERATORS. TYPICALLY, THE FINAL RESULT IS A SET OF m AND n INDICES CORRESPONDING TO THE x AND y COORDINATES ASSOCIATED WITH THE FOUR CORNERS COORDINATES OF A CUBIC BOX, WHICH SET IS THEREAFTER STORED IN A CORNER COORDINATE (OR INDICE) ARRAY.

(C)

FIG. 20D



STEP B11: COMPUTE THE AVERAGE RANGE VALUE OF THE CONTOUR POINTS CURRENTLY BUFFERED IN THE ODB SO AS TO PROVIDE AN AVERAGE HEIGHT VALUE FOR THE BOX, AND THEN, FOR EACH CORNER POINT IN THE CORNER COORDINATE ARRAY, USE THE COMPUTED AVERAGE RANGE VALUE TO COMPUTE THE z COORDINATE CORRESPONDING THERETO, AND REFERENCED WITH RESPECT TO THE GLOBAL COORDINATE FRAME OF REFERENCE.

STEP B12: COMPUTE THE x AND y COORDINATES ASSOCIATED WITH EACH CORNER POINT CURRENTLY BUFFERED IN THE CORNER COORDINATE ARRAY AND SPECIFIED BY INDICES m AND n. COORDINATES x AND y ARE REFERENCED WITH RESPECT TO THE GLOBAL COORDINATE FRAME.

/R

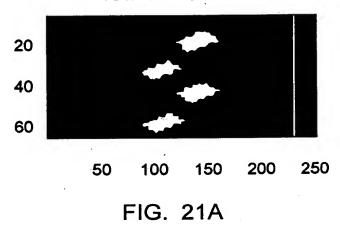
STEP B13: COMPUTE THE SURFACE AREA OF THE OBJECT REPRESENTED BY THE CONTOURS CURRENTLY REPRESENTED IN THE CONTOUR BUFFER, USING THE m,n COORDINATES ASSOCIATED WITH THE CORNER VERTICES m AND n CURRENTLY BUFFERED IN THE CORNER COORDINATE ARRAY.

S

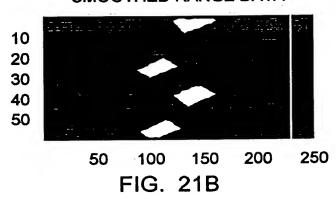
STEP B14: FOR THE SCANNED OBJECT, OUTPUT THE COMPUTED SURFACE AREA, OBJECT HEIGHT, AND CORNER x,y COORDINATES (VERTICES) REFERENCED WITH RESPECT TO THE GLOBAL COORDINATE REFERENCE FRAME.

70/116

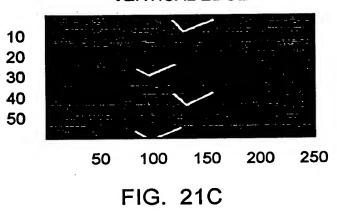
RAW RANGE DATA



SMOOTHED RANGE DATA



VERTICAL EDGE



71/116

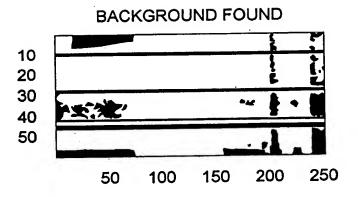
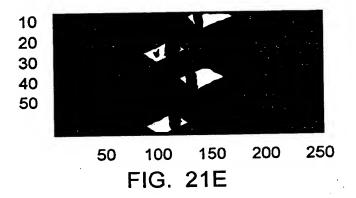
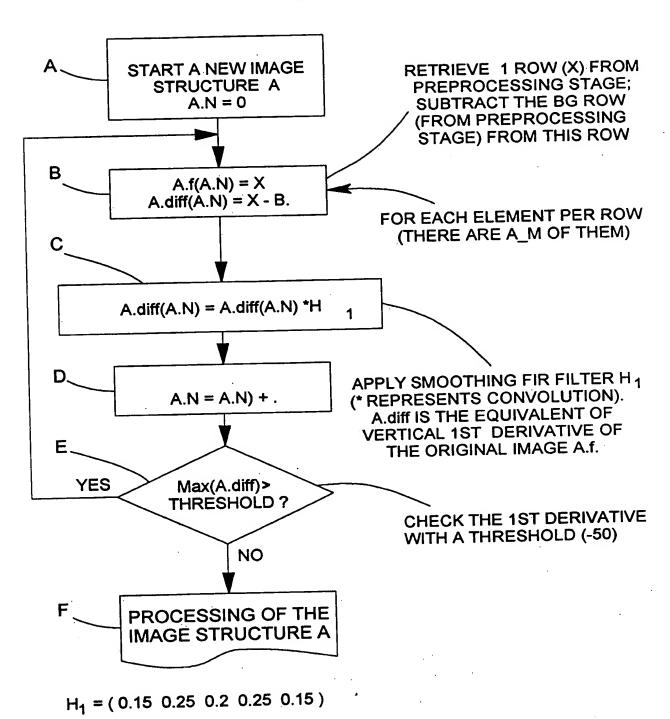


FIG. 21D

BACKGROUND ELIMINATED

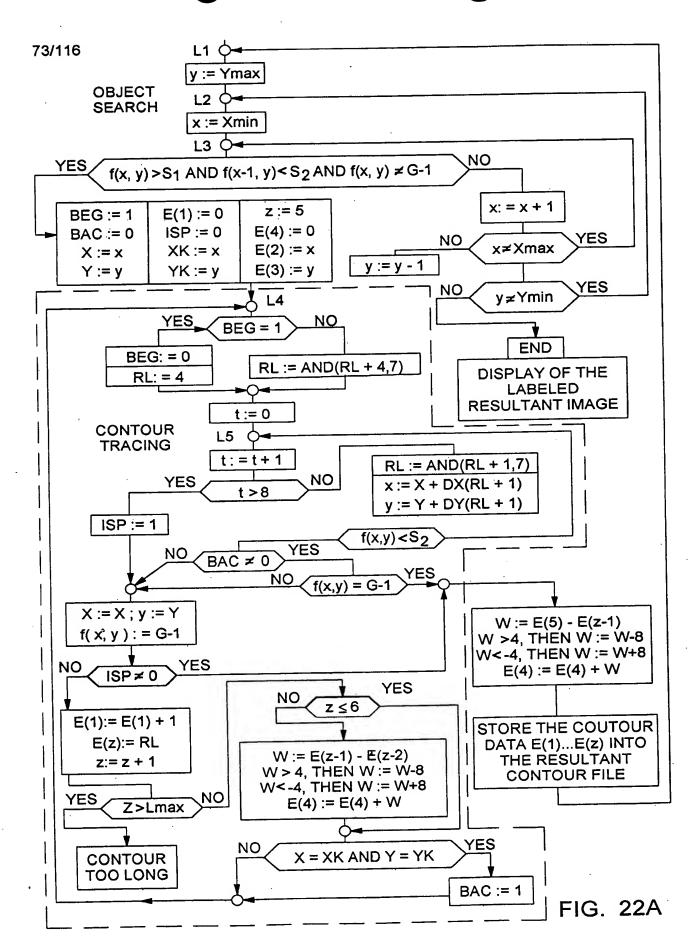






THIS FUNCTIONAL BLOCK RETRIEVES DATA ALREADY PRE-PROCESSED, COMPUTES VERTICAL FIRST DERIVATIVE, AND STORES THE RESULTS IN AN IMAGE STRUCTURE FOR FURTHER PROCESSING, SUCH AS COMPUTER TRACING, ETC.







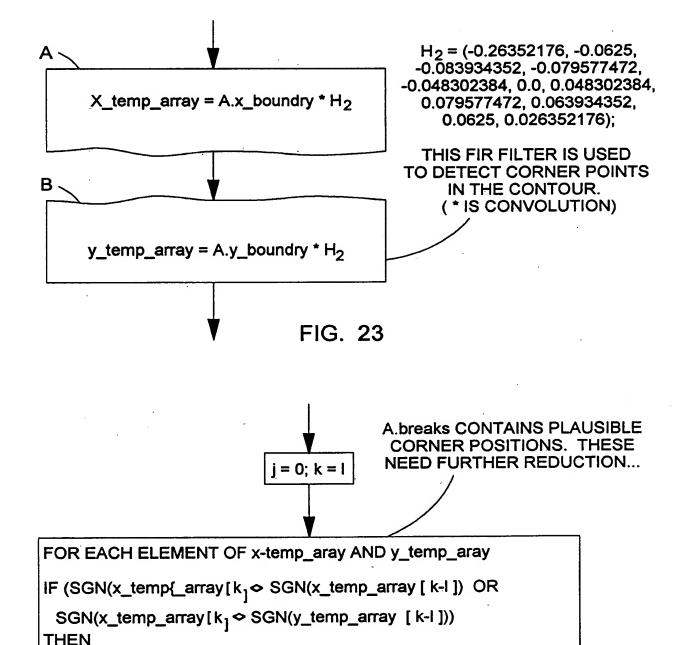


FIG. 24

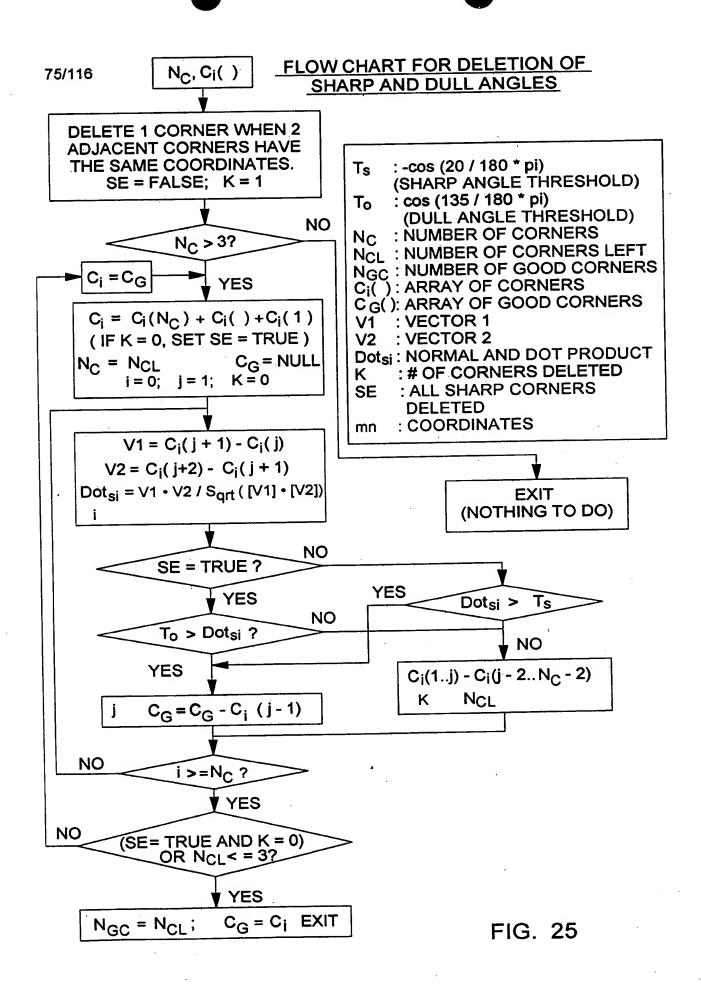
SGN(x) IS THE

ALEGEBRAIC SIGN AT x.

A.breaks[i] = k

j=j + l;

AND IF





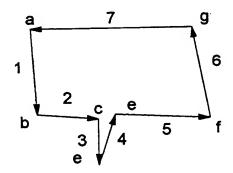


FIG. 26A

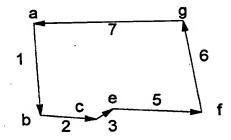


FIG. 26B

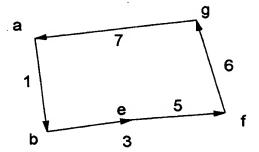


FIG. 26C

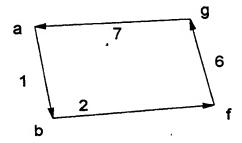


FIG. 26D

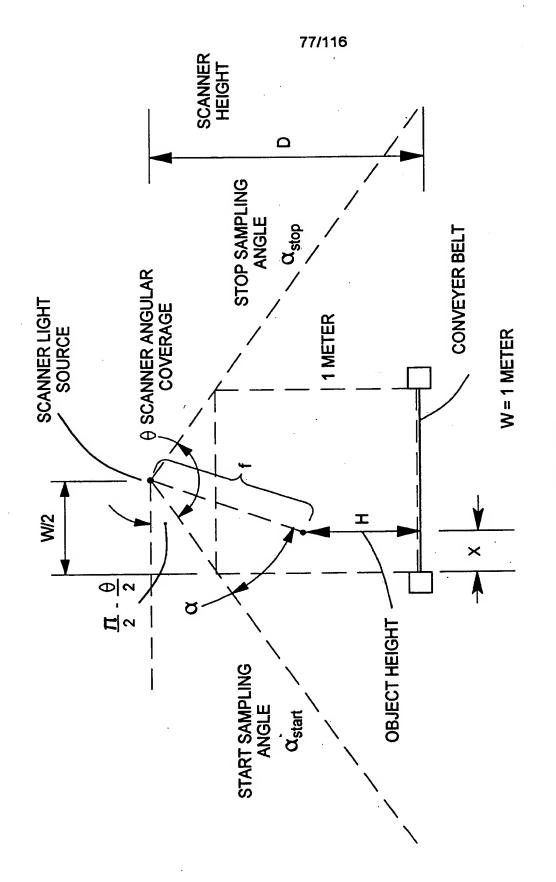
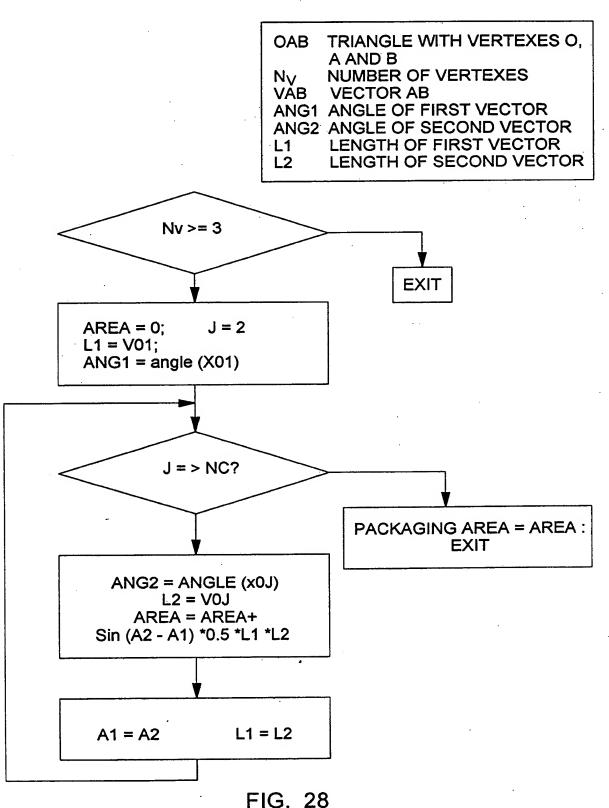


FIG. 27

78/116
FLOW CHART FOR PACKAGE AREA COMPUTATION





79/116

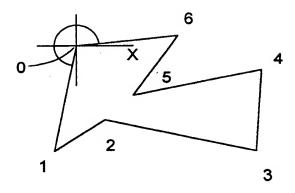


FIG. 29A

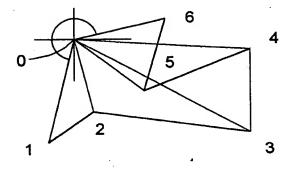


FIG. 29B

water and the second

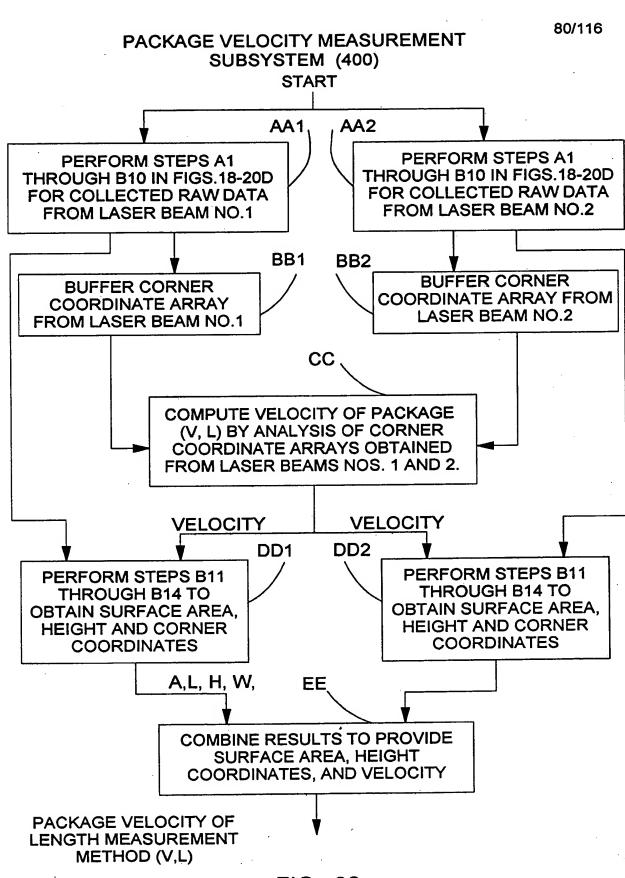


FIG. 30

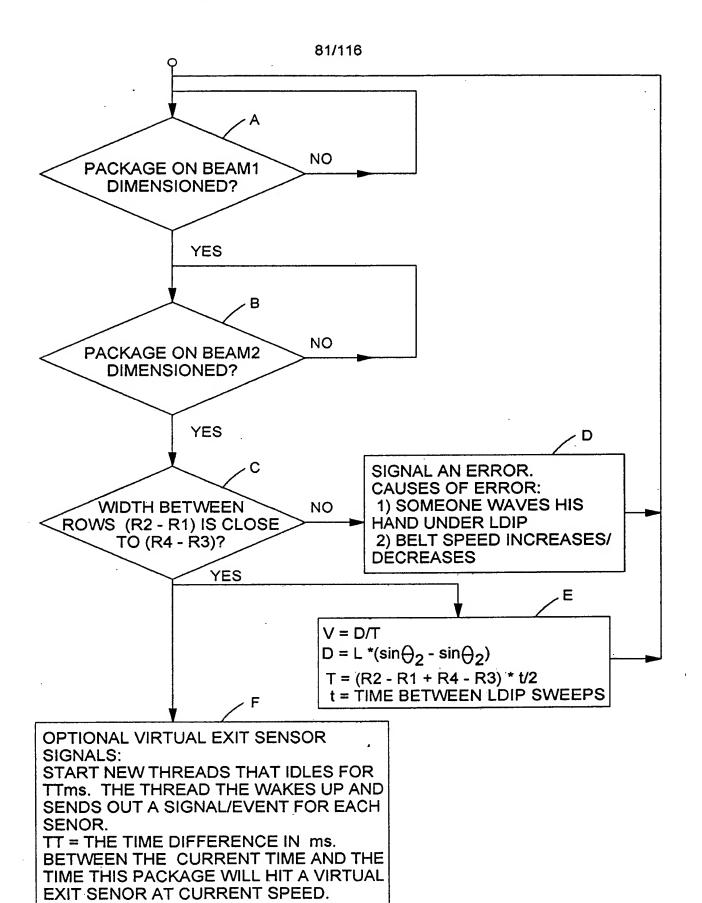
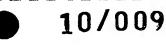


FIG. 31



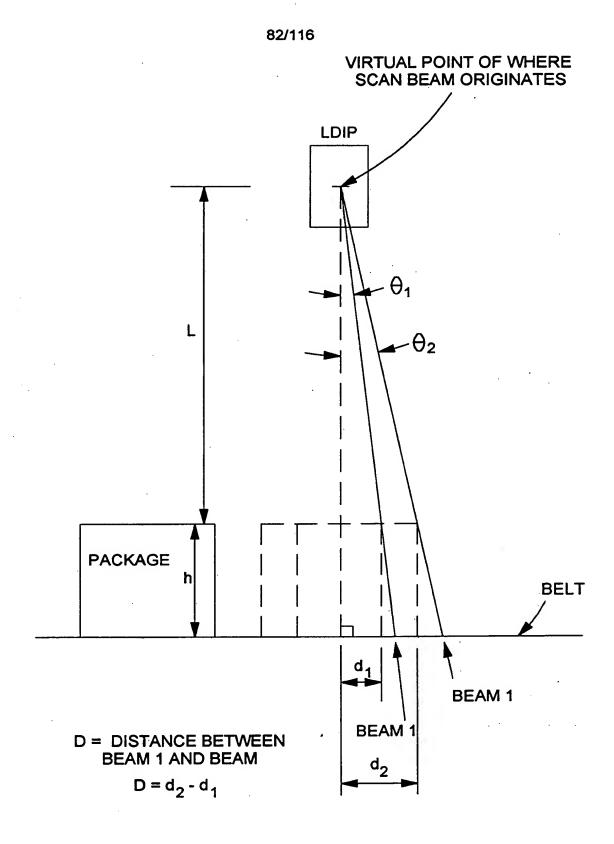


FIG. 32



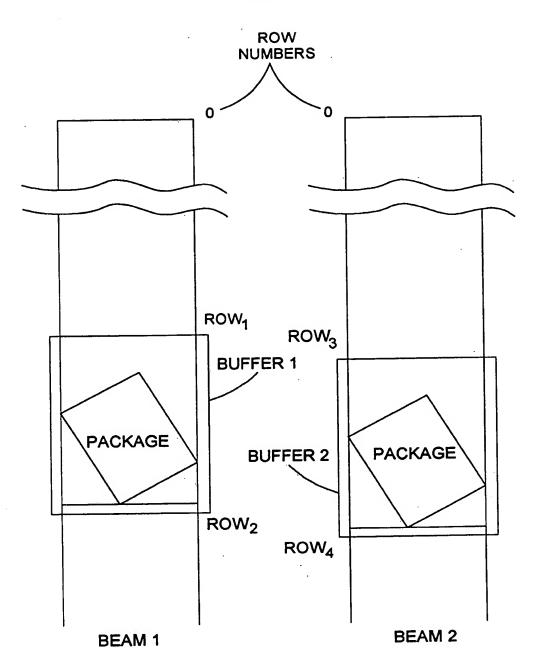


FIG. 33A

FIG. 33B



PACKAGE IN THE TUNNEL(PITT) INDICATION SUBSYSTEM (500)

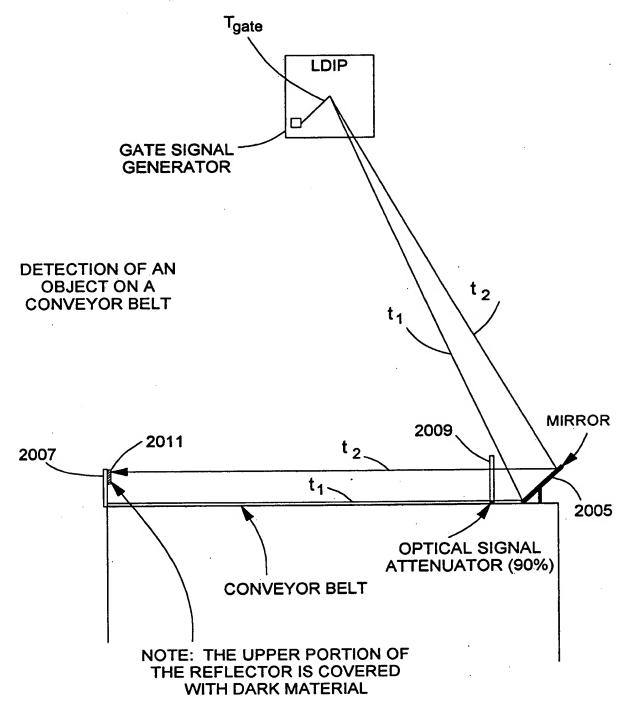


FIG. 33A



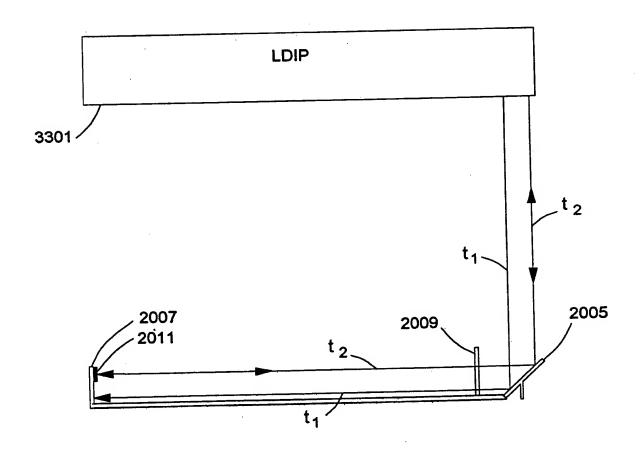


FIG. 33B

86/116

GENERATE "START-OF-OBJECT SENSING" CYCLE PULSE SIGNAL AS AM-LASER IS SCANNED ALONG EDGE OF CONVEYOR BELT. THE LADAR-BASED IMAGE AND PROFILING SUBSYSTEM OF THE PRESENT INVENTION.

B

USE "START-OF-OBJECT SENSING" CYCLE PULSE SIGNAL TO GENERATE A PREDEFINED TIME WINDOW OVER WHICH DETECTION OF OBJECT SENSING SIGNAL WILL OCCUR.

C

TRANSMIT AN OBJECT SENSING SIGNAL ACROSS THE CONVEYOR BELT, AND DETECT CHANGES IN THE INTENSITY OF THIS SIGNAL OVER THE PREDEFIED TIME WINDOW.

D

GENERATE AN OBJECT DETECTION SIGNAL IN RESPONSE TO THE DETECTION OF CHANGES IN INTENSITY IN THE OBJECT SENSING SIGNAL, INDICATIVE OF THE PRESENCE OF AN OBJECT (i.e.

FIG. 34

PACKAGE) MOVING ACROSS THE CONVEYOR BELT.



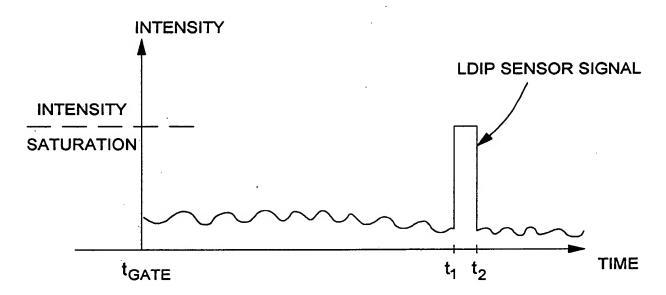


FIG. 35A

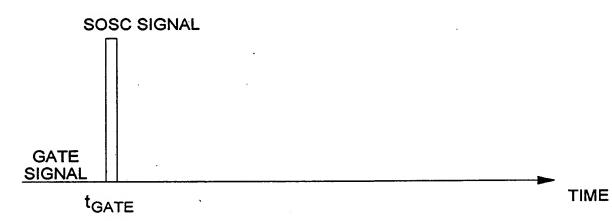


FIG. 35B

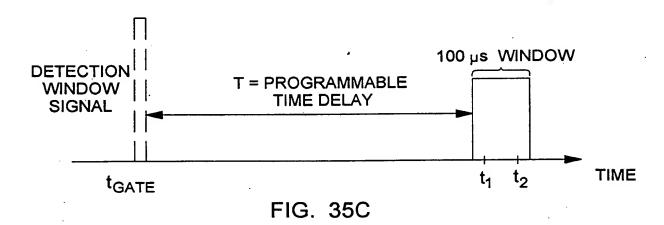


FIG. 36A

89

8

580 | 813 | 1129 | 276 | 161 | 286 | 404 | 411

160

97

12

-2

ا

TABLE 1

FIRST DERIVATIVE

FIR FILTER TABS -0.2 | 0.25 | -0.33 | 0.5 | -1 | 0 | 1 | -0.5 | 0.33 | -0.25 | 0.2

TABLE 2

FIG. 36B

TABLE 3

										Ξ			Ŋ								
φ	-5	2	9	42	18	105	172	463	594	684	197	105 172 463 594 684 197 105 79 102 338 375 387 177 96	79	102	338	375	387	177	96	72 61	61
 FIRS	TDE	ZIVA)]K																		
<u> </u>									-22.3	-123	-8.8	-22.3 -123 -8.8 -257 -191 205 184.3	-191	-205	184.3	429.3	429 3-153 182 -214 -45.9 1.783	182	-214	-45.9	1,783

FIG. 36C

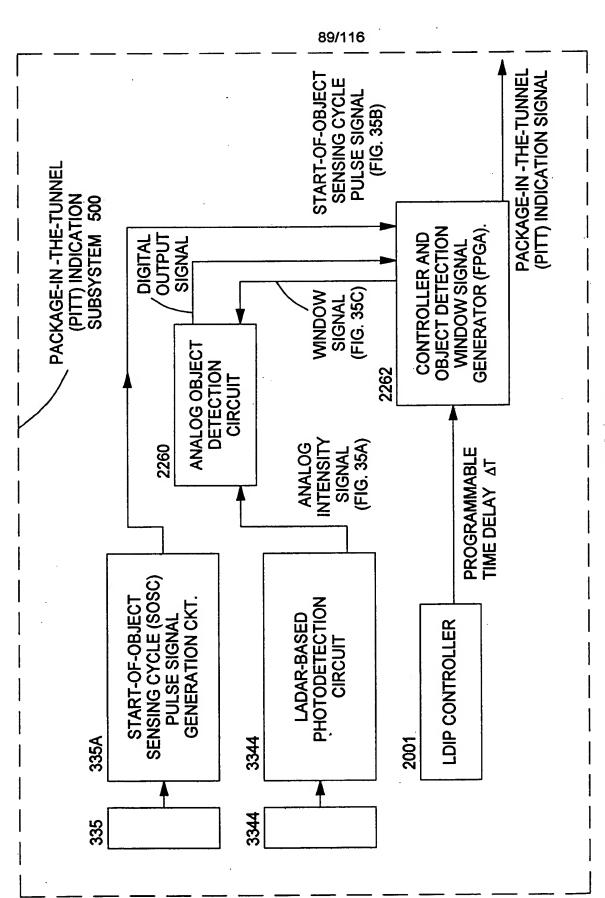
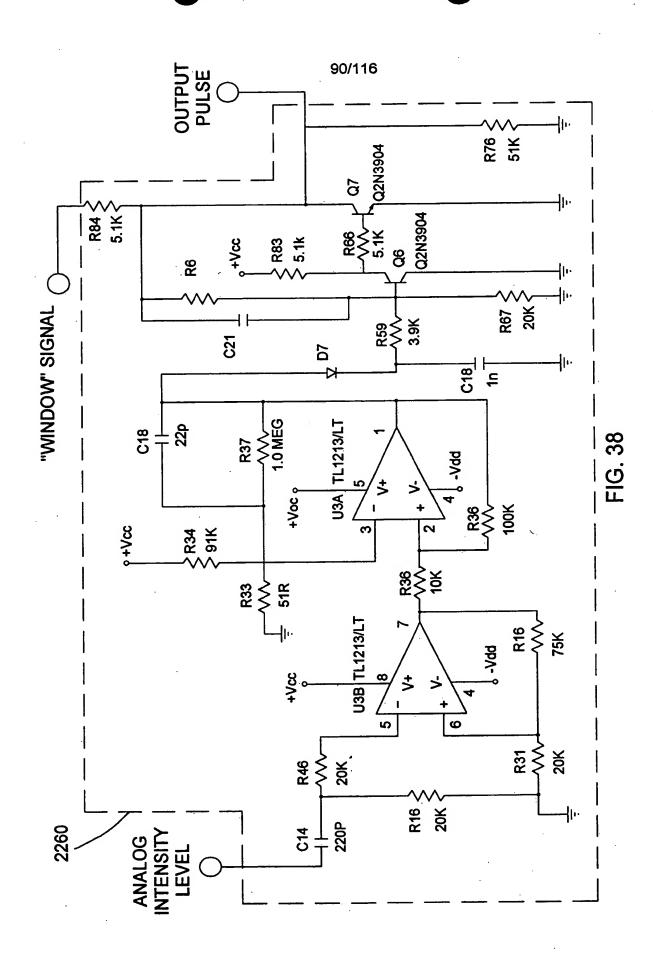
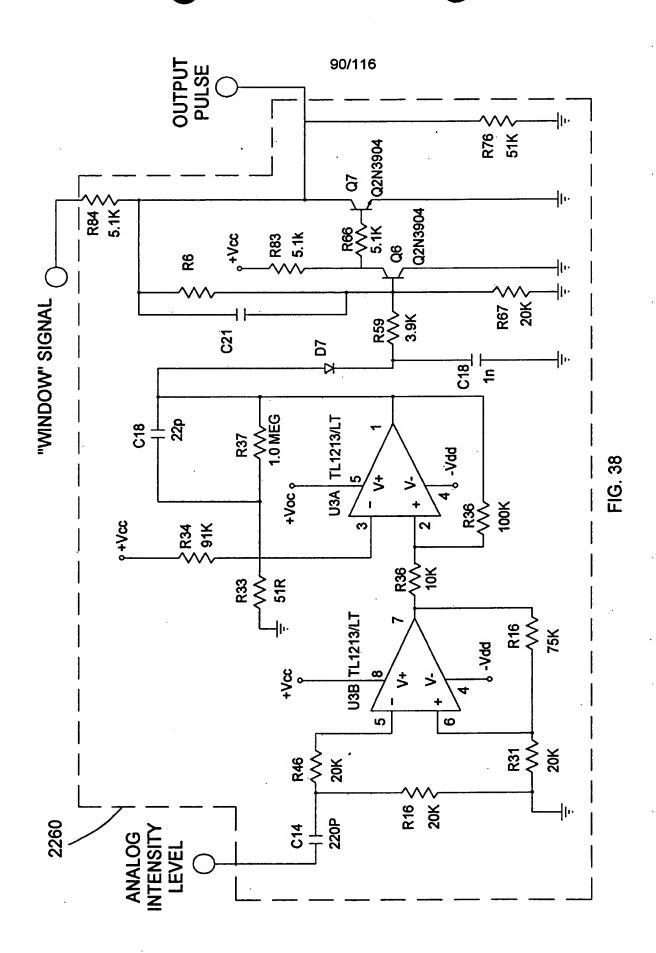
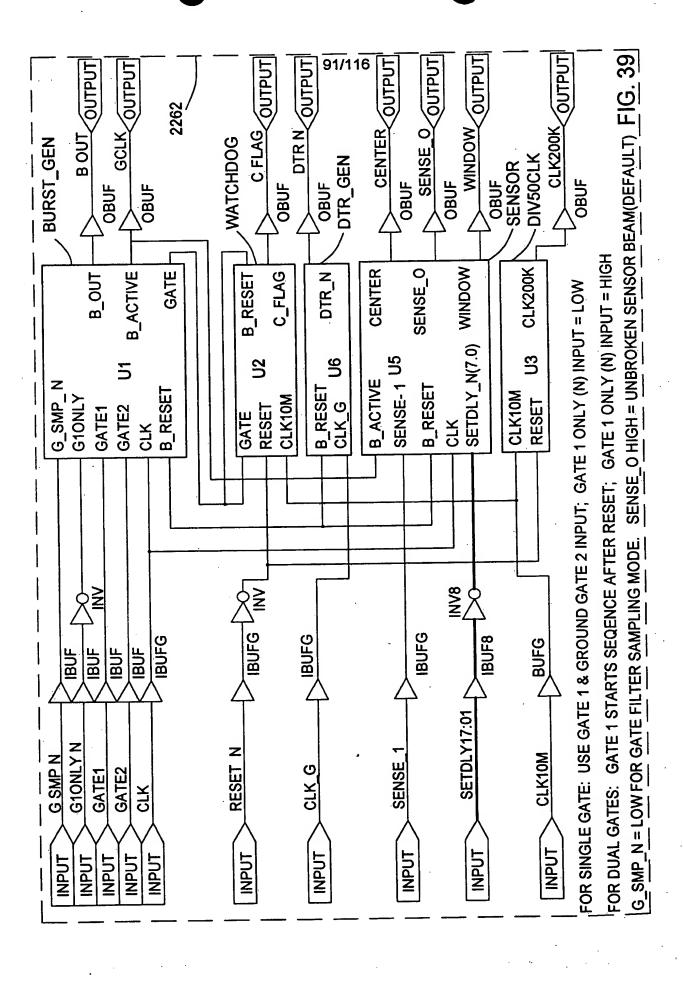


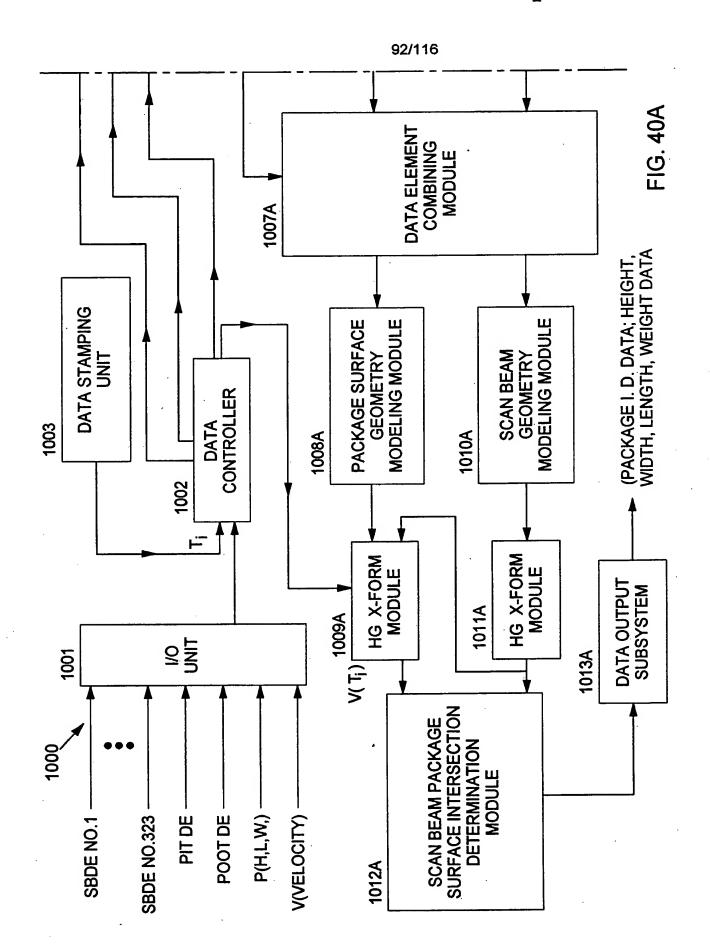
FIG. 37

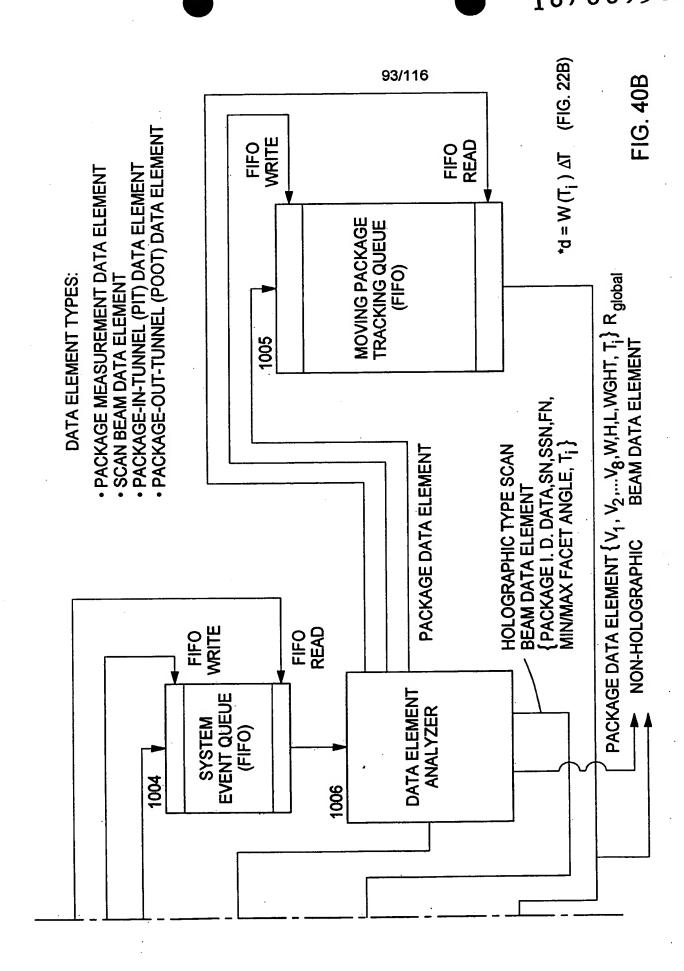
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DATA ELEMENT HANDLING RULES

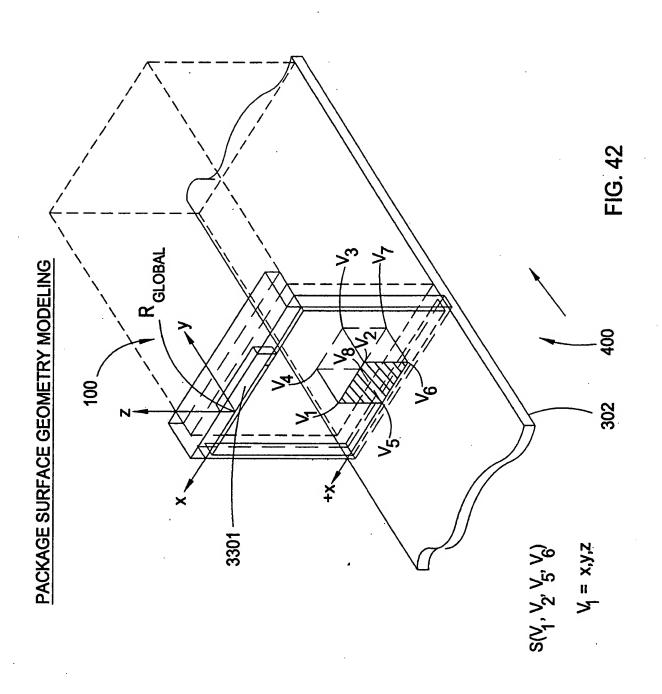
- 1. WHEN A PACKAGE DATA ELEMENT (PDE) OF ANY TYPE IS REMOVED FROM THE SYSTEM EVENT QUEUE, THEN IT IS PLACED IN THE MOVING PACKAGE TRACKING QUEUE
- 2. WHEN A SCAN BEAM DATA ELEMENT (SBDE) IS REMOVED FROM THE SYSTEM EVENT QUEUE, THEN IT IS COMBINED WITH EACH PACKAGE DATA ELEMENT IN THE MOVING PACKAGE TRACKING QUEUE AND THEN EACH RESULTING DATA ELEMENT PAIR IS PROCESSED ALONG THE PACKAGE DATA ELEMENT CHANNEL AND SCAN DATA ELEMENT CHANNEL AS SHOWN IN FIGS. 40A & 40B
- 3. WHEN A PACKAGE-IN-TUNNEL (PIT) DATA ELEMENT IS REMOVED FROM THE SYSTEM EVENT QUEUE, THEN THE OLDEST PACKAGE DATA ELEMENT IN THE MOVING PACKAGE TRACKING QUEUE IS REMOVED THERE FROM
- 4. WHEN A PACKAGE OUT-OF TUNNEL (POOT) DATA ELEMENT IS REMOVED FROM THE SYSTEM EVENT QUEUE, THEN THE FOLLOWING OPERATIONS ARE CARRIED OUT

FIG. 41A

- (a) IF THE TIME STAMP T_i ON THE REMOVED POOT DATA ELEMENT INDICATES THAT CORRESPONDING PACKAGE HAS MOVED OUT OF THE SCANNING TUNNEL, THEN REMOVE THE OLDEST PACKAGE DATA ELEMENT IN MOVING PACKAGE TRACKING QUEUE
- (b) IF THE TIME STAMP T; ON THE REMOVED POOT DATA ELEMENT INDICATES THAT THE CORRESPONDING PACKAGE IS STILL MOVING THROUGH THE SCANNING TUNNEL, THEN DO NOT REMOVE ANY PACKAGE DATA ELEMENT FROM THE MOVING PACKAGE TRACKING QUEUE.

FIG. 41B

96/116





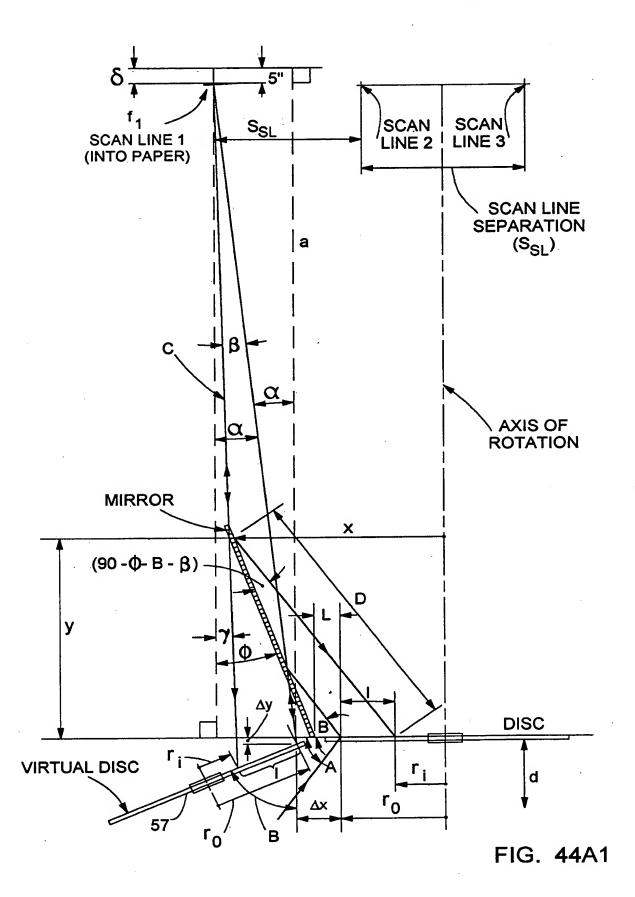
VECTOR-BASED SURFACE MODELING OF PACKAGES MOVING IN SCANNING TUNNEL

MATHEMATICAL FORM OF EACH SURFACE ON THE PACKAGE: VECTOR-BASED MODEL CONSISTING OF (1) AT LEAST THREE VERTICE POINTS WITHIN THE PLANE OF THE PACKAGE SURFACE, AND (2) NORMAL VECTOR FOR THE PLANE.

PROCEDURE:

- (1) USE POSITION VECTOR (REFERENCED TO X=0, Y=0,Z=0 IN R_{global}), FOR SPECIFYING THE POSITION OF EACH VERTEX IN THE PACKAGE SURFACE PLANE; AND
- (2) USE NORMAL VECTOR FOR SPECIFYING THE SURFACE DIRECTION OF THE PACKAGE SURFACE (AT WHICH LIGHT REFLECTS)
- (3) THEDE FOUR VECTORS S[ECIFU THE SURFACE OR THE PACKAGE IN COOEDINATE REFERENCE FROM R_{global}

FIG. 43



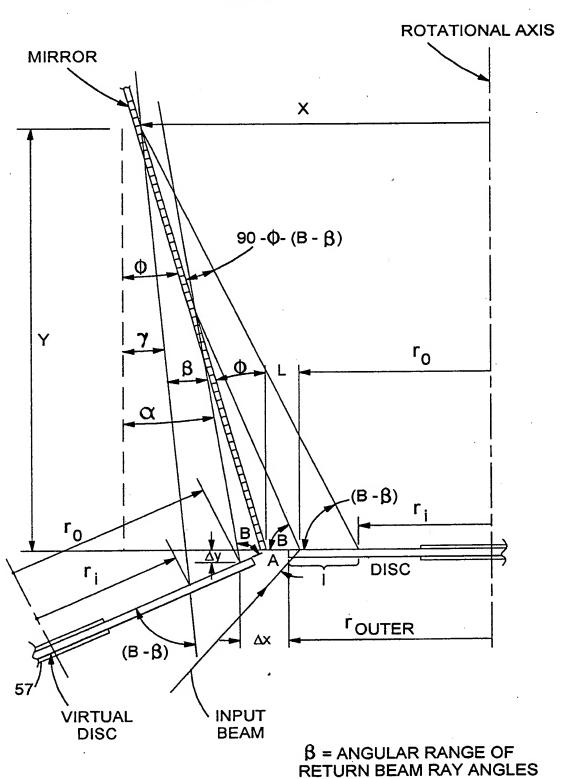


FIG. 44A2

- (1) THE RADIUS TO BEAM-INCIDENT-POINT ON THE HOLOGRAPHIC SCANNING DISC, ASSIGNED THE SYMBOLIC NOTATION " \mathbf{r}_0 "
- (2) SCANLINE SEPARATION BETWEEN ADJACENT SCANLINES AT THE FOCAL PLANE OF THE (i,J)-TH SCANLINE, ASSIGNED THE SYMBOLIC NOTATION "S_{SL}"
- (3) THE SCANLINE LENGTH (MEASURED INTO PAPER) FOR THE (i,J)-TH SCANLINE, ASSIGNED THE SYMBOLIC NOTATION "LSL"
- (4) THE DISTANCE MEASURED FROM THE SCANNING DISC TO THE FOCAL PLANE OF THE (i,J)-TH SCANLINE, ASSIGNED THE SYMBOLIC NOTATION $a_{\rm i}$
- (5) THE DISTANCE FROM RADIUS TO BEAM-INCIDENT-POINT $r_{\hbox{\scriptsize O}}$ TO BEAM FOLDING MIRROR, ASSIGNED THE SYMBOLIC NOTATION "L"
- (6) THE TILT ANGLE OF THE J-TH BEAM FOLDING MIRROR ASSOCIATED WITH GENERATION OF THE (i,J)-TH SCANLINE, ASSIGNED THE SYMBOLIC NOTATION " φ_i "
- (7) THE TILT ANGLE OF THE VIRTUAL SCANNING DISC, ASSIGNED THE SYMBOLIC NOTATION " 20 "
- (8) THE LATERAL SHIFT OF THE BEAM INCIDENT POINT ON THE VIRTUAL SCANNING DISC, ASSIGNED THE SYMBOLIC NOTATION "AX"
- (9) THE VERTICAL SHIFT OF THE BEAM INCIDENT POINT ON THE VIRTUAL SCANNING DISC, ASSIGNED THE SYMBOLIC NOTATION "AY"
- (10) THE DISTANCE FROM THE ROTATION AXIS TO THE BEAM INCIDENT POINT ON THE VIRTUAL SCANNING DISC, ASSIGNED THE SYMBOLIC NOTATION " Γ_0 + Δ X"
- (11) THE DISTANCE FROM THE BEAM INCIDENT POINT ON THE VIRTUAL SCANNING DISC TO THE FOCAL PLANE WITHIN WHICH THE (i,J)-TH SCANLINE RESIDES, ASSIGNED THE SYMBOLIC NOTATION " f; "
- (12) THE DIAMETER OF THE CROSS-SECTION OF THE LASER BEAM SCANNING STATION, ASSIGNED THE SYMBOLIC NOTATION "d $_{\rm BEAM}$ "
- (13) THE ANGULAR GAP BETWEEN ADJACENT HOLOGRAPHIC SCANNING FACETS, ASSIGNED THE SYMBOLIC NOTATION " ${\rm d}_{\rm GAP}$ "
- (14) THE OUTER RADIUS OF THE AVAILABLE LIGHT COLLECTION REGION ON THE HOLOGRAPHIC SCANNING DISC, ASSIGNED THE SYMBOLIC NOTATION " $r_{\rm OUTER}$ "

FIG. 44B1

- (15) THE INNER RADIUS OF THE AVAILABLE LIGHT COLLECTION REGION ON THE HOLOGRAPHIC SCANNING FACET, ASSIGNED THE SYMBOLIC NOTATION " r INNER
- (16) ONE-HALF OF THE DEPTH OF FIELD OF THE (i, J)-TH SCANLINE, ASSIGNED THE SYMBOLIC NOTATION "δ"
- (17) THE DISTANCE FROM THE MAXIMUM READ DISTANCE (f_i + 5") TO THE INNER RADIUS r; OF THE SCANNING FACET, ASSIGNED THE SYMBOLIC NOTATION "C"
- (18) THE OUTER RAY ANGLE MEASURED RELATIVE TO THE NORMAL TO THE i-TH HOLOGRAPHIC FACET, ASSIGNED THE SYMBOLIC NOTATION "Q"
- (19) THE INNER RAY ANGLE MEASURED RELATIVE TO THE NORMAL TO THE i-TH HOLOGRAPHIC FACET, ASSIGNED THE SYMBOLIC NOTATION "7"
- (20) THE LIGHT COLLECTION ANGLE MEASURED FROM THE FOCAL POINT OR THE I-TH FACET TO THE LIGHT COLLECTION AREA OF THE SCANNING FACET, ASSIGNED THE SYMBOLIC NOTATION "B"
- (21) THE INTERSECTION OF THE BEAM FOLDING MIRROR AND LINE C, ASSIGNED THE SYMBOLIC NOTATION "X"
- (21A) THE INTERSECTION OF THE BEAM FOLDING MIRROR AND LINE C, ASSIGNED THE SYMBOLIC NOTATION "Y"
- (22) THE DISTANCE MEASURED FROM THE INNER RADIUS TO THE POINT OF MIRROR INTERSECTION, ASSIGNED THE SYMBOLIC NOTATION "D"
- (23) THE DISTANCE MEASURED FROM THE BASE OF THE SCANNER HOUSING TO THE TOP OF THE j-TH BEAM FOLDING MIRROR, ASSIGNED THE SYMBOLIC NOTATION "h"
- (24) THE DISTANCE MEASURED FROM THE SCANNING DISC TO THE " d " BASE OF THE HOLOGRAPHIC, ASSIGNED THE SYMBOLIC NOTATION
- (25) THE FOCAL LENGTH OF THE i-TH HOLOGRAPHIC SCANNING FACET FROM THE CORRESPONDING FOCAL PLANE WITHIN THE SCANNING VOLUME, ASSIGNED THE SYMBOLIC NOTATION "fi"
- (26) INCIDENT BEAM ANGLE, ASSIGNED THE SYMBOLIC NOTATION "A;"
- (27) DIFFRACTED BEAM ANGLE, ASSIGNED THE SYMBOLIC NOTATION "B_i"

FIG. 44B2

- (28) THE ANGLE OF THE J-TH LASER BEAM MEASURED FROM THE VERTICAL, ASSIGNED THE SYMBOLIC NOTATION " α "
- (29) THE SCAN ANGLE OF THE LASER BEAM, ASSIGNED THE SYMBOLIC NOTATION " $\theta_{\rm si}$ "
- (30) THE SCAN MULTIPLICATION FACTOR FOR THE I-TH HOLOGRAPHIC FACET, ASSIGNED THE SYMBOLIC NOTATION "M;"
- (31) THE FACET ROTATION ANGLE FOR THE i-TH HOLOGRAPHIC FACET, ASSIGNED THE SYMBOLIC NOTATION " θ_{ROTi} "
- (32) ADJUSTED FACET ROTATION ANGLE ACCOUNTING FOR DEADTIME, ASSIGNED THE SYMBOLIC NOTATION " θ'_{ROTi} "
- (33) THE LIGHT COLLECTION EFFICIENCY FACTOR FOR THE i-TH HOLOGRAPHIC FACET, NORMALIZED RELATIVE TO THE 16TH FACET, ASSIGNED THE SYMBOLIC NOTATION " $\xi_{\rm i}$ "
- (34) THE MAXIMUM LIGHT COLLECTION FOR THE i-TH HOLOGRAPHIC FACET, ASSIGNED THE SYMBOLIC NOTATION "Area;"
- (35) THE BEAM SPEED AT THE CENTER OF THE (i, j)-TH SCANLINE, ASSIGNED THE SYMBOLIC NOTATION "V_{CENTER}"
- (36) THE ANGLE OF SKEW OF THE DIFFRACTED LASER BEAM AT THE CENTER OF THE i-TH HOLOGRAPHIC FACET, ASSIGNED THE SYMBOLIC NOTATION " φ_{SKEW} "
- (37) THE MAXIMUM BEAM SPEED OF ALL LASER BEAMS PRODUCED BY THE HOLOGRAPHIC SCANNING DISC, ASSIGNED THE SYMBOLIC NOTATION " $V_{\rm MAX}$ "
- (38) THE MINIMUM BEAM SPEED OF ALL LASER BEAMS PRODUCED BY THE HOLOGRAPHIC SCANNING DISC, ASSIGNED THE SYMBOLIC NOTATION " $V_{\rm MIN}$ "
- (39) THE RATIO OF THE MAXIMUM BEAM SPEED TO THE MINIMUM BEAM SPEED, ASSIGNED THE SYMBOLIC NOTATION " $V_{\rm MAX}/V_{\rm MIN}$ "
- (40) THE DEVIATION OF THE LIGHT RAYS REFLECTED OFF THE PARABOLIC LIGHT REFLECTING MIRROR BENEATH THE SCANNING DISC, FROM THE BRAGG ANGLE FOR THE FACET, ASSIGNED THE SYMBOLIC NOTATION " $\delta_{\rm a}$ "

PARAMETER EQUATION USED IN THE SPREADSHEET DESIGN OF THE SCANNER

(1)
$$\Delta x := L (1 + \cos(2\Phi))$$

(2)
$$\Delta y$$
 := L sin (2 Φ)

(3)
$$\Delta y := r_0 + \Delta x$$

(4) C :=
$$\sqrt{(f+\delta)^2 + I^2 + 2(f+\delta)I\cos(B)}$$

LAW OF COSINES, WHERE: $I = r_{outter} - r_{inner}$

$$\beta = \alpha - \gamma = B + 2\phi - 90 - \gamma$$

(5)
$$\alpha := B - 90 + 2\Phi$$

(6)
$$r := \alpha - \cos \left[\frac{(f+\delta)^2 + C^2 - I^2}{2(f+\delta)C} \right]$$

$$(7) \quad \beta \quad := \quad \alpha - \gamma$$

(8)
$$X := D \cos (B - \beta) + r_i$$

(9) Y := D sin (B-
$$\beta$$
)

(10) D :=
$$\frac{[r_0 + L - r_i] \sin (90 +)}{\sin (90 - B + \beta - \Phi)}$$
 LAW OF SINES

$$(11)$$
 h := Y+d

FIG. 44C1

(12)
$$f_i := \sqrt{a_i^2 + [m S_{SL} - [r_0 + \Delta x]]^2}$$

m IS A FACTOR THAT VARIES FROM SCAN LINE TO SCAN LINE AND DETERMINED BY SCAN LINE SEPARATION AND DISTANCE FROM THE ROTATIONAL AXIS OF THE DISC.

(13)
$$B_{i} := \operatorname{atan} \left[\left[\frac{m \, S_{SL} - \left[r_{0} + \Delta x \right]}{a_{i}} \right] \right] + 90 - 2 \, \Phi$$

(14)
$$\Phi_{Si}$$
 : = 2 atan $\left[\frac{\frac{1}{2} \text{ ScanLineLength}}{f_i} \right]$

(15)
$$M_i := \frac{r_0}{f_i} + \cos(\lambda_1) + \cos(B_i)$$

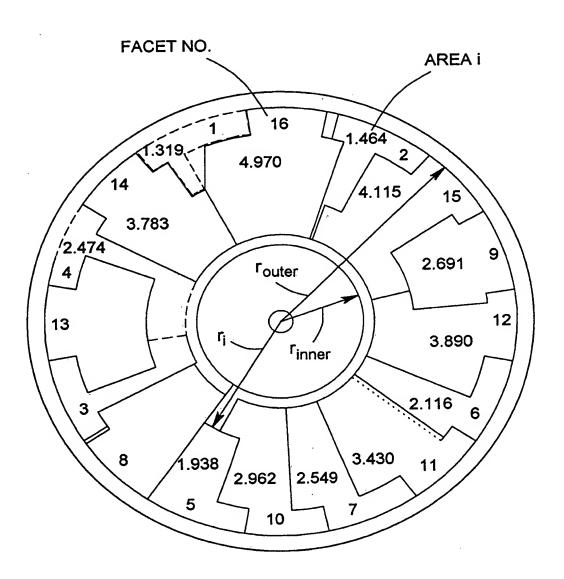
(16)
$$\Theta_{\text{roti}} := \frac{\Theta_{\text{Si}}}{M_i}$$

(17)
$$\Theta'_{roti}$$
 := Θ_{roti} + $\frac{d_{beam}}{r_o}$ + $\frac{d_{gap}}{r_o}$ Θ_{dead}

(18)
$$\xi_i$$
 : = $\left[\frac{f_i}{f_{16}}\right]^2 \frac{\sin\left[B_{16}\right]}{\sin\left(B_i\right)}$ H_i

(19) Area_i : =
$$\pi \left[r_{outter}^2 + r_{inner}^2 \right] \frac{\xi_i}{\frac{16}{\sum_{i=1}^{16} \left[\xi_i \right]}}$$
 i = 1,2,...16

105/116



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FIG. 44D

VECTOR MODELING OF LASER SCAN BEAMS IN HOLOGRAPHIC SCANNING SUBSYSTEMS

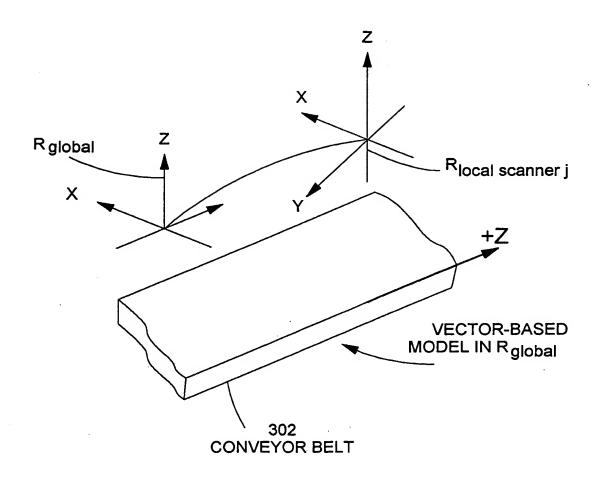
MATHEMATICAL FORM FOR EACH LASER SCAN BEAM: VECTOR-BASED MODEL OF OPTICAL PATH OF BEAM FROM DISC TO MIRROR TO FOCAL PLANE (∞)

PROCEDURE:

- (1) USE POSITION VECTOR REFERENCED FROM X=0, Y=0, Z=O IN R_{local scanner}, FOR SPECIFYIED THE STARTING POINT OF LASER SCAN BEAM ON DISC, AND DIRECTION VECTOR FOR SPECIFYING THE DIRECTION OF LASER BEAM THE BEAM FOLDING MIRROR; AND (2) USE POSITION VECTOR FOR SPECIFYING POINT ON MIRROR WHERE BEAM IS REFLECTED FROM BEAM FOLDING MIRROR TOWARDS FOCAL PLANE OF FACET, EXTENDING TO INFINITY, AND DIRECTION VECTOR FOR SPECIFYING THE DIRECTION OF LASER BEAM TOWARDS DESIGNATED FOCAL PLANE
- (3) THESE FOUR VECTORS SPECIFY THE LASER BEAM RAY IN LOCAL COORDINATE REFERENCE $\mathbf{R}_{\text{local scanner}}$

107/116

VECTOR-BASED MODEL IN R_{local scanner}



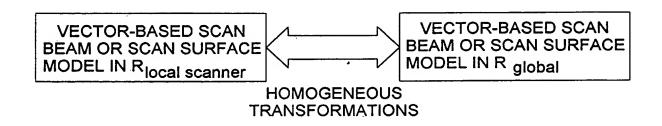


FIG. 46



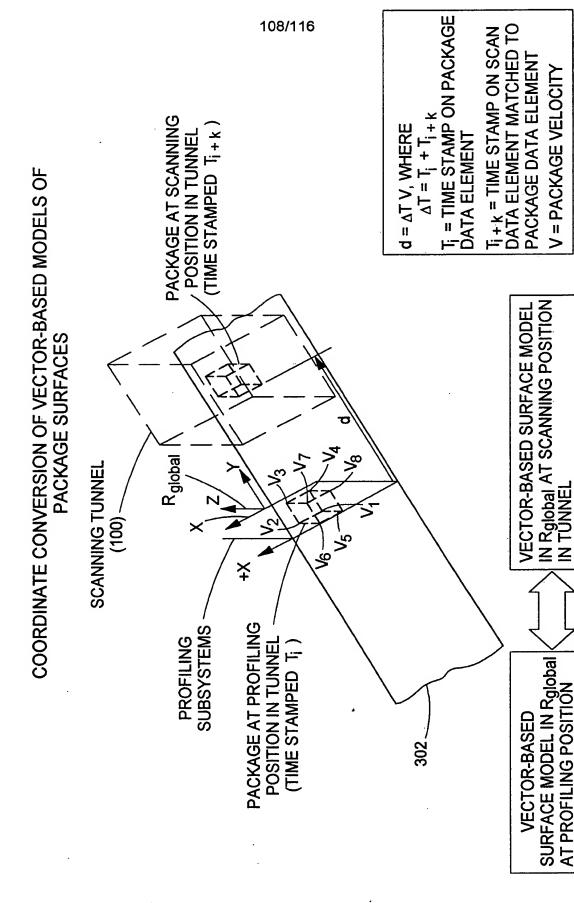


FIG. 47

TRANSFORMATIONS f(d) HOMOGENEOUS

SCAN BEAM/PACKAGE SURFACE INTERSECTION DETERMINATION METHOD FOR SCAN DATA ELEMENTS PRODUCED FROM HOLOGRAPHIC SCANNING SUBSYSTEMS

USING THE MINIMUM AND MAXIMUM SCANNING MODELS OF THE LASER SCAN BEAM, DETERMINE THE INTERSECTION POINT BETWEEN THE SCAN RAY AND A SURFACE ON THE PACKAGE (USING THE VECTOR-BASED MODELS THEREOF), REFERENCED TO THE GLOBAL COORDINATE FRAME R_{global}

IF AN INTERSECTION POINT IS DETERMINED, THEN CONFIRM THAT SIGN OF THE NORMAL VECTOR OF THE SURFACE IS OPPOSITE THE SIGN OF SCAN RAY DIRECTION VECTOR

IF SIGN OF NORMAL VECTOR IS OPPOSITE SIGN OF SCAN RAY DIRECTION VECTOR, THEN DETERMINE IF INTERSECTION POINT (FOUND IN STEP ABOVE) FALLS WITH SPATIAL BOUNDARIES OF THE PACKAGE SURFACE

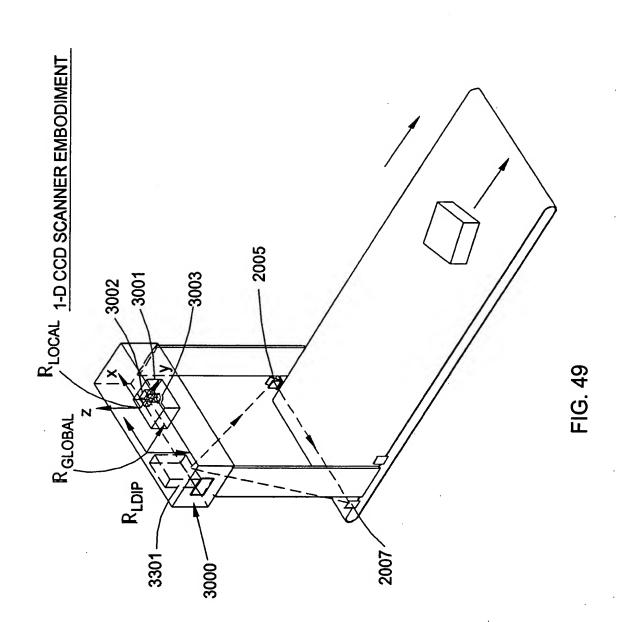
110/116

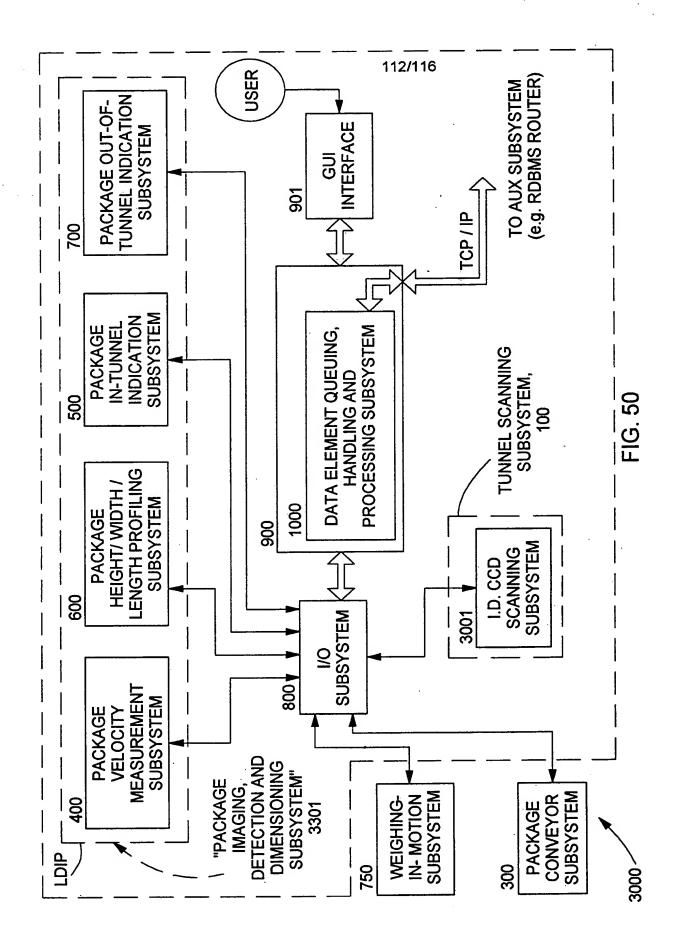


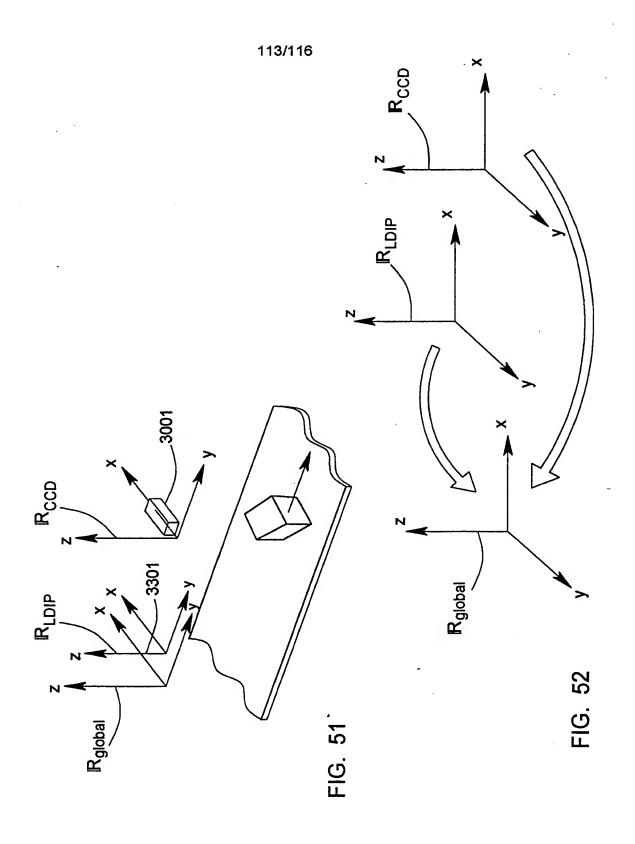
IF INTERSECTION POINT FALLS WITHIN BOUNDRIES OF SURFACE, THEN OUTPUT OF A DATA ELEMENT IN OUTPUT QUEUE COMPRISING THE PACKAGE I.D. DATA AND THE DIMENSIONS AND MEASUREMENTS (e.g. L, H, W AND WEIGHT) OF PACKAGE FOR USE BY OTHER SUBSYSTEMS

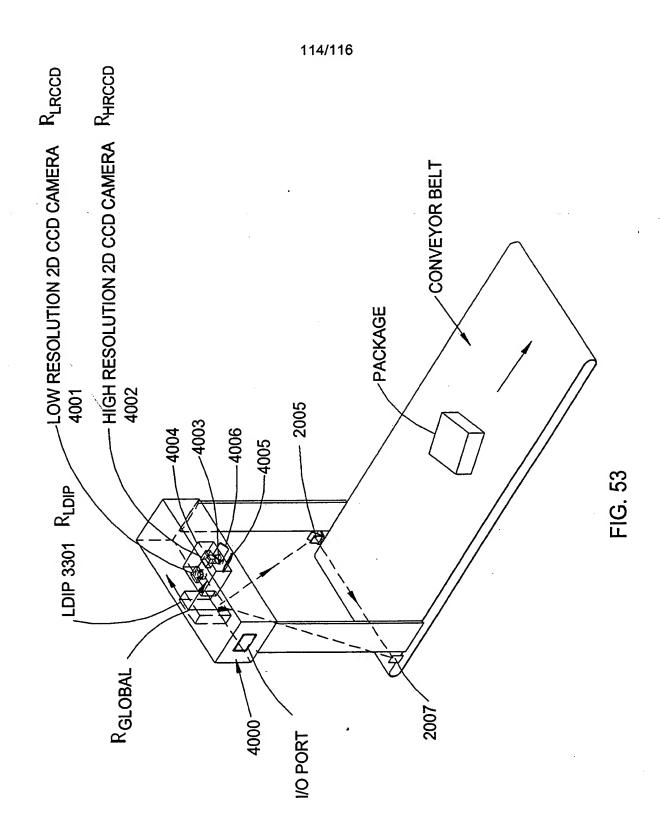
FIG. 48B

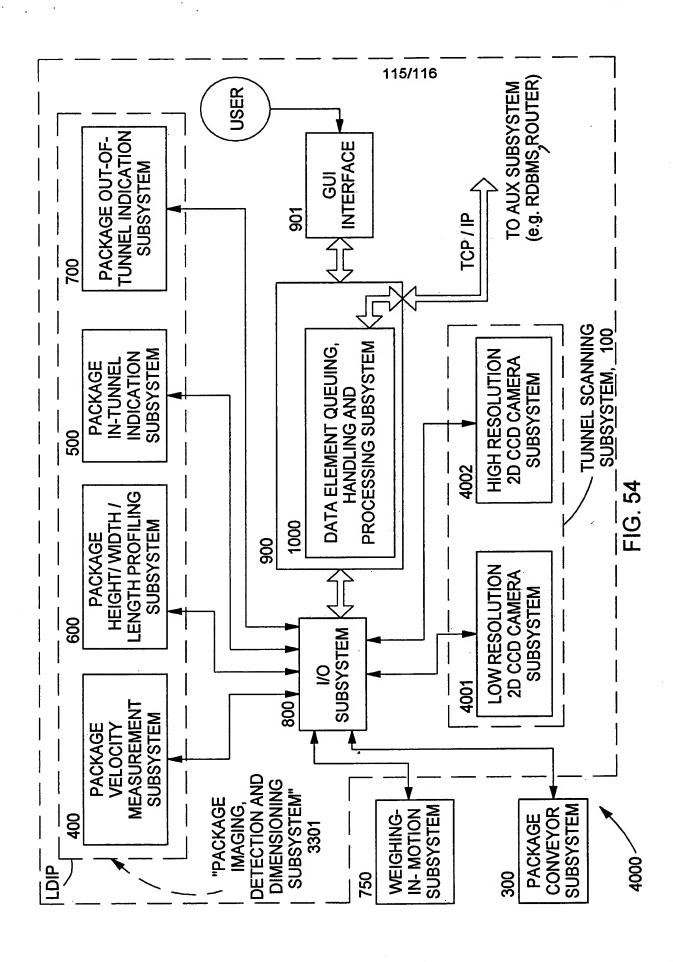












116/116

